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CORPS OF ENGINEERS, U. S. ARMY

**FLOOD CONTROL PROJECT, HOOSIC RIVER
ADAMS, MASSACHUSETTS**

REPORT NO. 1

MODEL INVESTIGATION OF PHASE I OF IMPROVEMENT WORKS



TECHNICAL MEMORANDUM NO. 2-339

CONDUCTED FOR

NEW YORK DISTRICT, CORPS OF ENGINEERS

BY

WATERWAYS EXPERIMENT STATION

VICKSBURG, MISSISSIPPI

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PREFACE

Model investigation of the Hoosic River at Adams, Massachusetts, was authorized by the Chief of Engineers in 2nd indorsement, dated 3 April 1950, to basic letter, dated 28 March 1950, from the New York District through the North Atlantic Division to the Office, Chief of Engineers. The first phase of the investigation, reported herein, was conducted by the Waterways Experiment Station during the period April 1950 to June 1950. An additional phase of investigation to study further channel improvements upstream from those reported herein will be conducted at a later date.

During the course of the first phase of the study Mr. P. H. Jaenichen of the North Atlantic Division, and Messrs. F. L. Panuzio and S. S. Haendel of the New York District, visited the Waterways Experiment Station at frequent intervals to discuss test results and correlate these results with design work concurrently being carried on in the District Office.

Personnel at the Experiment Station actively connected with the model study were Messrs. F. R. Brown, T. E. Murphy, T. J. Buntin, G. B. Sims, Jr., and C. M. Wright.

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SUMMARY

Model investigations of the Hoosic River at Adams, Massachusetts, were conducted to verify the hydraulic design and to determine what changes, if any, should be made for safety, for greater hydraulic efficiency, or for economy. Particular attention was given to the flow conditions around the superelevated curves, in the stilling basins, and at the junctions of the culvert flume with Tophet Brook, and Tophet Brook with the Hoosic River. A 1:20-scale model reproduced approximately 2800 ft of the main channel of the Hoosic River and about 1300 ft of the lower portion of Tophet Brook.

Flow conditions around curves were satisfactory as was the distribution of flow at the entrance to the drop structure on the main channel. However, for reasons of economy the stilling basin was moved downstream approximately 500 ft and the width of the channel upstream from the stilling basin narrowed from 75 to 40 ft. The removal of baffle piers from the stilling basin improved flow conditions, especially at capacity discharge of 13,000 cfs.

Flow conditions at the original junction of the main channel of the Hoosic River and Tophet Brook were unsatisfactory. However, a change in radius of curvature of the right wall alignment effected the desired improvement. The angle of intersection at the junction of the culvert flume and Tophet Brook as originally designed was such that transverse waves were set up in the channel below the junction. These waves were carried into the drop structure downstream in Tophet Brook and caused the flow to be confined to the left side of the basin with an eddy on

the right side. A change in radius of curvature of the right wall alignment of the culvert flume improved flow conditions.

FLOOD CONTROL PROJECT, HOOSIC RIVER, ADAMS, MASSACHUSETTS

MODEL INVESTIGATION OF PHASE 1 OF IMPROVEMENT WORKS

PART I: INTRODUCTION

1. The Hoosic River rises in northwestern Massachusetts (plate 1), flows generally north and northwest, crossing the southwest corner of Vermont to the vicinity of Eagle Bridge, New York, where it turns west and joins the Hudson River about 16 miles above Troy, New York. It is 66 miles long and has a drainage area of 713 square miles. Adams, Massachusetts, is situated on the south branch of the Hoosic River, about 8 miles below the source of the river.

2. The flood-control project for Adams provides for local improvement of the channel of the Hoosic River through the town (plate 2). The upstream portion of the improvement works will consist of a rectangular concrete channel varying from 40 to 75 ft in width. The downstream portion will consist of an excavated earth channel supplemented by concrete walls and levees, with paving at proposed check dams and critical sections; width of the channel will vary from 65 to 90 ft. Over-all length of the improved river section will be about 12,000 ft. Approximately 1200 ft of Tophet Brook, which joins the Hoosic River at Adams, also will be improved by construction of a rectangular concrete channel 35 ft in width. Similar improvement works on the Hoosic River are to be made downstream at North Adams, Massachusetts, and are described in Waterways Experiment Station Technical Memorandum No. 2-338, entitled "Flood Control Project, Hoosic River, North Adams, Massachusetts,"

dated February 1952.

3. Flow will be carried through the paved portions of the improvement works at velocities up to about 35 ft per sec. It was necessary to design the channel bends with spiral transition curves and superelevated inverts since existing structures fixed channel alignment. A stilling basin will be used on both the main stream and Tophet Brook at the downstream end of the paved channel sections to reduce the high velocities of the flow before it enters the improved earth channel which has a riprapped bed for a short distance. The main river channel is designed to pass a maximum flow of 13,000 cfs above Tophet Brook and Tophet Brook is designed to pass a maximum flow of 5,000 cfs. The project design flood is 8,200 cfs in the main channel and 2,000 cfs in Tophet Brook. Water-surface elevations in the riprapped section of the improved channel are controlled by an overflow weir located about 1,000 ft downstream from the junction of Tophet Brook and the main channel.

4. Although the original design of the channel improvement plan* was in accordance with good hydraulic design practices, the results obtained from the North Adams model tests indicated the desirability of verifying computations by means of a model study. Specifically, information was desired as to possible changes in bottom grade, width of channel, superelevation at bends, and junction sections.

* Prototype design based on "Hydraulic Model Study, Los Angeles River Improvement, Whitsett Avenue to Tujunga Wash," Los Angeles District, CE, July 1949.

PART II: THE MODEL

Description

5. The model was constructed to a scale ratio, model to prototype, of 1:20 and reproduced the main channel of Hoosic River from station 35+00 to station 63+00 and Tophet Brook from station 0+00 to station 12+37.2. Photographs 1 and 2 show the model area reproduced while plates 3 and 5 show the original and recommended designs, respectively, of the improvement works included in the first phase of the construction program. The downstream 217 ft of a culvert flume joining Tophet Brook also was added to the model (plate 13). One additional phase of construction and testing, to be accomplished at a later date, will involve tests of channel improvements upstream from those described herein (plate 2).

6. The channel was built of plywood supported by timbers and a steel frame which could be adjusted to provide a variation of longitudinal slope. The bottom and walls of the improved channel sections were constructed of 1/8-in.-thick, plastic-coated plywood to permit ready alteration.

Scale Relationships

7. The accepted equations of hydraulic similitude, based upon the Froudian relationships, were used to express the mathematical relationships between the dimensions and the hydraulic quantities of the model and the prototype. The general relationships are presented in the following tabulation:

<u>Dimension</u>	<u>Scale Relationship</u>
Length	$L_r = 1:20$
Area	$A_r = L_r^2 = 1:400$
Velocity	$V_r = L_r^{1/2} = 1:4.472$
Time	$T_r = L_r^{1/2} = 1:4.472$
Discharge	$Q_r = L_r^{5/2} = 1:1789$
Roughness coefficient	$N_r = L_r^{1/6} = 1:1.648$

Appurtenances and Their Application

8. The water used in the operation of the model was supplied by centrifugal pumps. The quantities of water entering Tophet Brook and the main channel were measured by 8-in. and 10-in. elbow meters, respectively. Flow entering the culvert flume was measured by a 6-in. Van Leer weir. After passing through the model, the water was returned to the sump through an underground conduit. The tailwater elevations in the downstream end of the model were controlled by means of an adjustable tailgate. The initial water depths at the entrance to each channel were adjusted in accordance with design computations by means of slide gates. Steel rails, set to grade along either side of the model, provided a datum plane for the use of measuring devices. Water-surface elevations were measured by means of portable point gages mounted on aluminum channels supported by steel rails. Velocities were measured by means of a pitot tube.

PART III: NARRATIVE OF TESTS

Original Design - Plan 1

9. The model of the Hoosic River at Adams, Massachusetts, was originally constructed as shown on plate 3. The drop structure and stilling basin on the main channel were located at station 55+25. Construction of Tophet Brook extended only to station 4+31.98. Immediately following its completion, the model was demonstrated to representatives of the North Atlantic Division and New York District Offices. Certain alterations were requested and accomplished while representatives of the above offices were still in Vicksburg. Therefore, data on the original design of the proposed improvement works were confined to a few photographs of flow conditions (photographs 3-7).

10. Flow conditions in the improved channel section and around the superelevated curve upstream from the drop structure were excellent. The stilling basin (plate 4) functioned satisfactorily for a discharge of 8,200 cfs, but for a discharge of 13,000 cfs the hydraulic jump was swept from the basin. Flow conditions in the improved channel downstream from the stilling basin were unsatisfactory as a result of the wave action set up by the turbulent stilling basin action. The flow from Tophet Brook into the main channel also created large waves in the main channel which were considered objectionable (photographs 8 and 9).

Plan 2

11. The first revision tested (plan 2) involved the movement of

the drop structure and stilling basin on the main channel downstream to station 51+50 (plate 5). The channel upstream was flared from a width of 40 ft at station 55+25 to 75 ft at station 53+50; the 75-ft-wide channel was maintained to the drop structure at station 51+50. Movement of the drop structure downstream from its original position was desired because of construction details involved rather than because of hydraulic considerations. No changes were made in either the main river section downstream from the drop structure or in Tophet Brook, although revisions had been indicated by tests of the original design. Flow conditions with the stilling basin moved downstream were identical with those described for the original design. Therefore no photographs or other data were procured.

Plan 3

12. The channel of plan 3 involved the maintenance of the 40-ft width upstream from the drop structure to station 53+25, from thence it flared to a width of 75 ft at station 51+50, the beginning of the drop structure (plate 5).

13. Flow conditions in the main channel and through the flared section upstream from the drop structure were very smooth (photographs 10 and 11). Velocity distribution at the entrance to the drop structure also was fairly uniform (plate 6). Flow conditions in the stilling basin were identical with those observed in the basin of original design. Removal of the baffle piers from the stilling basin, however, resulted in improved basin action (photographs 12 and 13). A good hydraulic jump resulted for discharges of 8,200 and 13,000 cfs. Flow conditions in the

channel immediately downstream from the stilling basin are shown in photographs 14 and 15. Velocities over the end sill of the stilling basin and in the channel downstream are shown on plates 7 and 8. Relocation of the drop structure had no effect on flow conditions at the junction with Tophet Brook (photographs 16 and 17) or upstream from the fixed overflow weir at the lower end of the model (photograph 18).

Plan 4

14. Plan 4 embodied all the improvements made to the drop structure and channel upstream of plan 3 and included, in addition, a revised alignment of Tophet Brook at the junction with Hoosic River (plate 5 and photograph 19).

15. Flow conditions at the junction of the main river channel and Tophet Brook were improved considerably by realignment of the right wall of Tophet Brook (photographs 20 and 21). The distribution of velocities in the main channel at and downstream from the junction was more uniform with the revised wall alignment (plates 9 and 10). Velocities were all downstream in direction, whereas with the original alignment, some upstream flow existed adjacent to the right wall of the main channel downstream from the junction. Water-surface profiles measured in the main channel for design (8,200 cfs) and capacity (13,000 cfs) flows supplemented by discharges of 2,000 cfs and 5,000 cfs, respectively, from Tophet Brook are shown on plates 11 and 12. Also shown for comparative purposes are computed water-surface profiles. Observed water-surface elevations, in general, were below the computed elevations in the area downstream from the drop structure. The model coefficient of roughness,

"n" in Manning's formula, was found to average about 0.0097 in the lower part of the main channel. This roughness value is equivalent to a prototype n value of 0.016. Model coefficients of roughness in the Hoosic River upstream from the drop structure and in Tophet Brook averaged about 0.0085 which is equivalent to a prototype roughness value of 0.014.

Tophet Brook

16. The original model limits reproduced only the lower 432 ft of Tophet Brook. The proposed plan of channel improvement was revised by the New York District, during the course of the model study, requiring the extension of the Tophet Brook channel and the addition of a culvert flume junction (plate 13). Total design flow in Tophet Brook was 2,000 cfs with 360 cfs contributed by the culvert flume and 1,640 cfs contributed by Tophet Brook. Total capacity flow was 5,000 cfs with 900 cfs contributed by the culvert flume and 4,100 cfs contributed by Tophet Brook. Flow entering Tophet Brook from the culvert flume of initial design caused a series of transverse waves downstream from the junction (photographs 22 and 23). These waves continued into the Tophet Brook drop structure, station 2+62.04, causing the flow to pile up along the left wall with resulting eddies along the right wall (photographs 24 and 25). Velocity measurements at various cross sections in Tophet Brook indicated the effect of culvert flow (plates 14-17). Velocities immediately upstream from the junction (plate 14) were fairly uniform across the channel whereas velocities downstream from the junction were dependent upon the location of the waves created by culvert discharge. Water-surface profiles in Tophet Brook with the culvert

flume discharging are shown on plates 18 and 19.

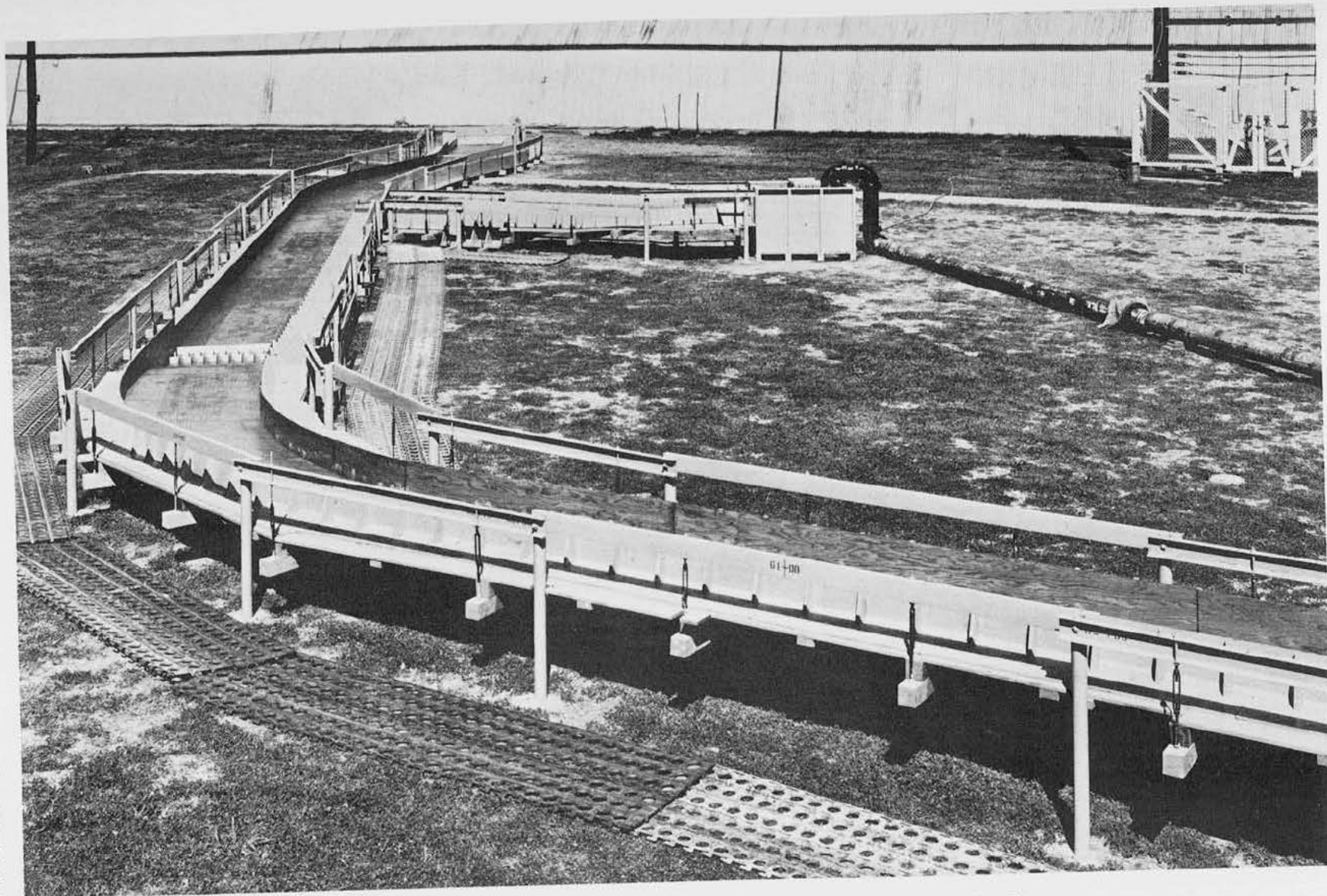
17. The alignment of the downstream end of the culvert flume as it joined Tophet Brook was revised as shown on plate 13 in an effort to improve flow distribution. Tests of the revised alignment indicated that the desired effect had been obtained (photographs 26 and 27). The transverse wave action noted in the original design was reduced. Flow conditions in the drop structure and stilling basin were improved (photographs 28 and 29). Velocity distribution in Tophet Brook also was more uniform (plates 20-23). Flow conditions at the junction of Tophet Brook and the Hoosic River for the recommended design with capacity flows in both streams are shown in photograph 30.

PART IV: CONCLUSIONS AND RECOMMENDATIONS

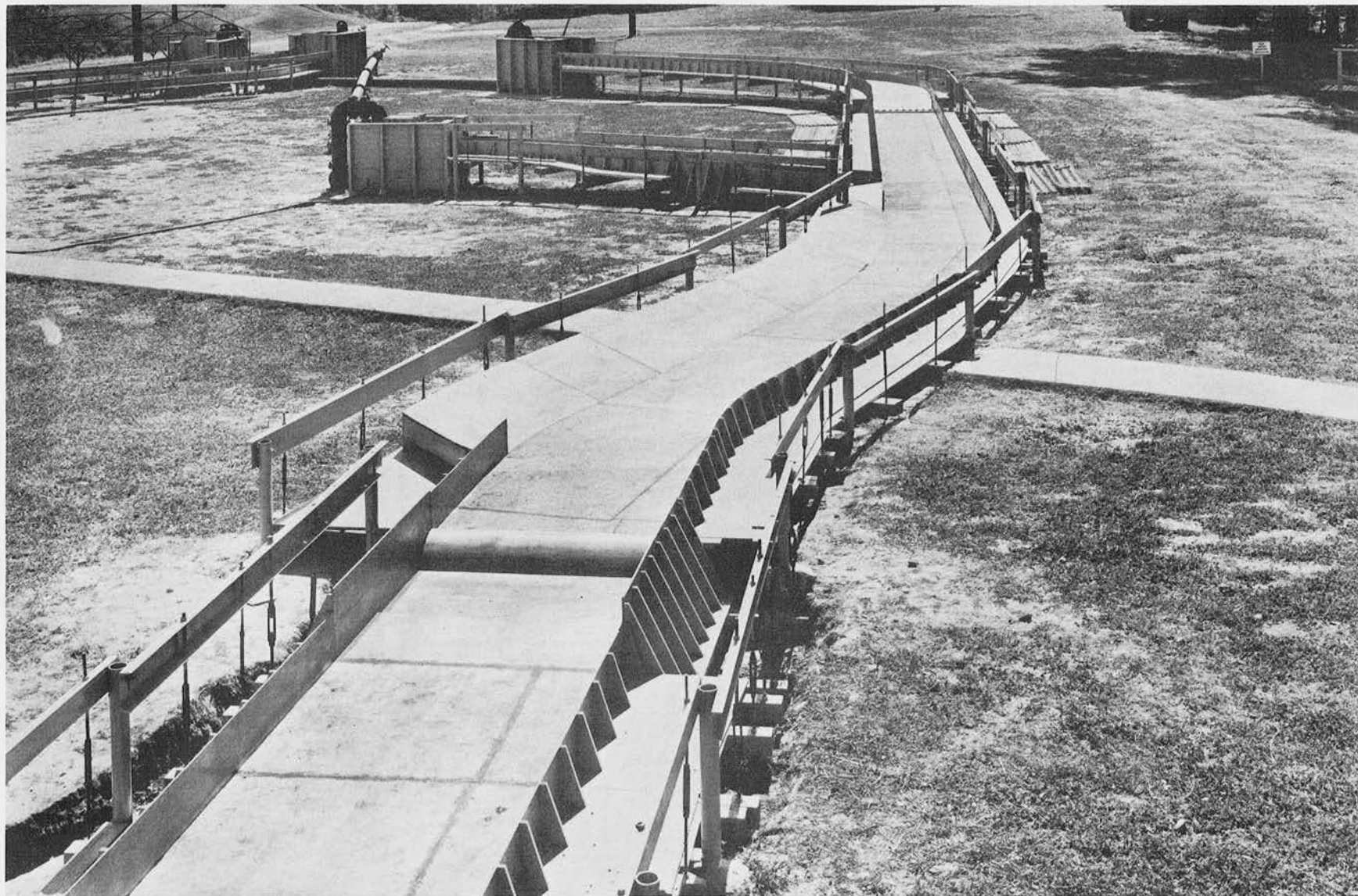
18. Tests of the first phase of improvement works on the Hoosic River at Adams, Massachusetts, indicated that the superelevated inverts of the high velocity channel upstream from the drop structure functioned satisfactorily. The drop structure and stilling basin operated satisfactorily at either station 55+25 (original location) or station 51+50 (revised location) provided the baffle piers were eliminated. Elimination of the baffle piers improved basin performance at the maximum discharge of 13,000 cfs. Some economy in construction was effected by location of the drop structure at station 51+50 as the channel width was reduced from 75 ft to 40 ft for a distance of 200 ft.

19. The original junctions of Tophet Brook with Hoosic River and the culvert flume with Tophet Brook were unsatisfactory. Realignment of the right wall of Tophet Brook and the culvert flume at the junction points provided the desired flow conditions.

PHOTOGRAPHS



Downstream view, Adams model. Hoosic River, original design



Upstream view, Adams model. Hoosic River, original design



Original design, main channel. Station 63+00 to station 55+00
Discharge 8,200 cfs



Original design, stilling basin
Discharge 8,200 cfs



Original design, main channel. Station 63+00 to station 55+00
Discharge 13,000 cfs

PHOTOGRAPH 6



Original design, stilling basin
Discharge 13,000 cfs



Original design, stilling basin with baffle piers
Discharge 13,000 cfs

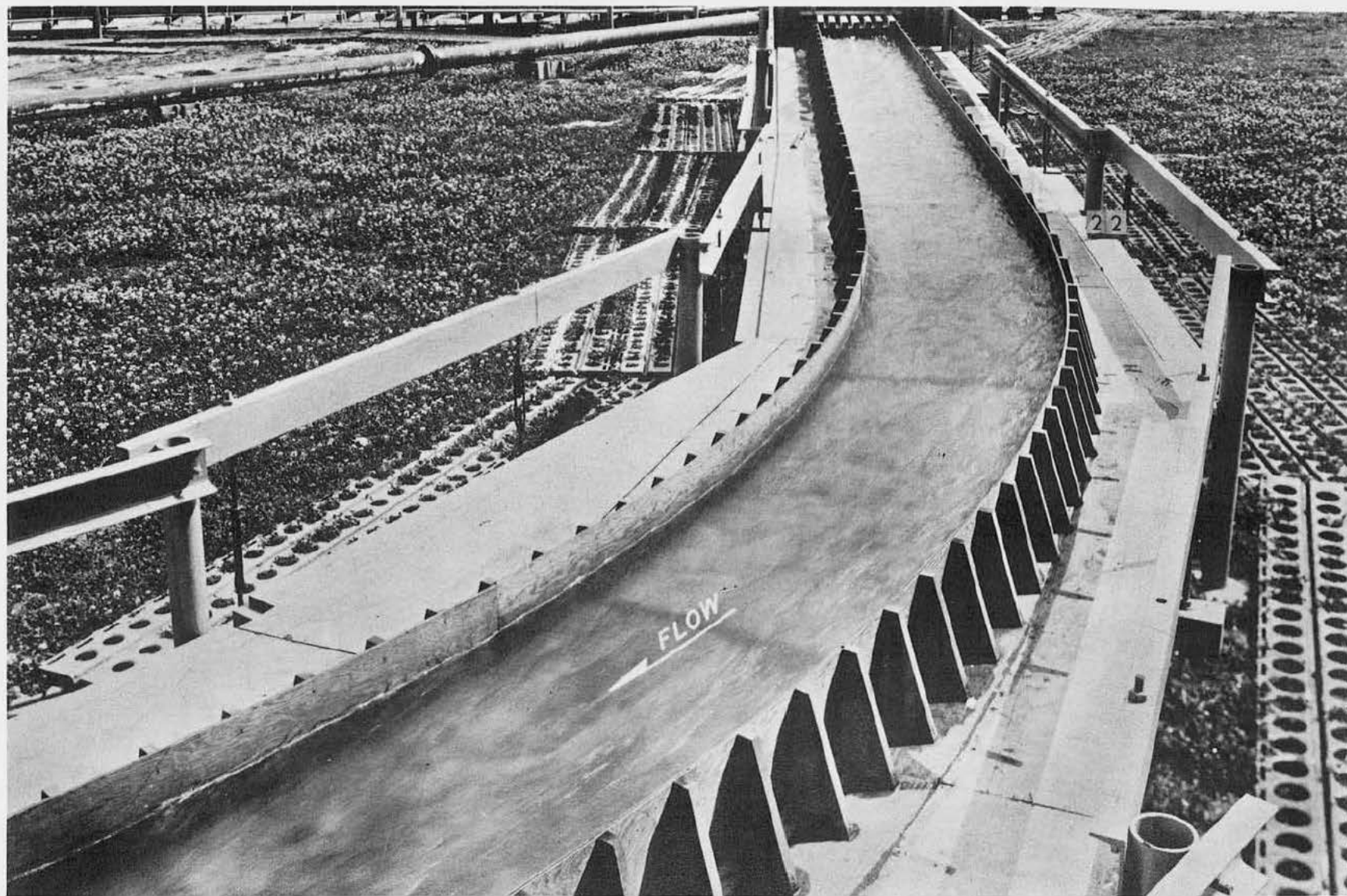


Original design, junction Tophet Brook
Discharge: Hoosic River 8,200 cfs; Tophet Brook 2,000 cfs

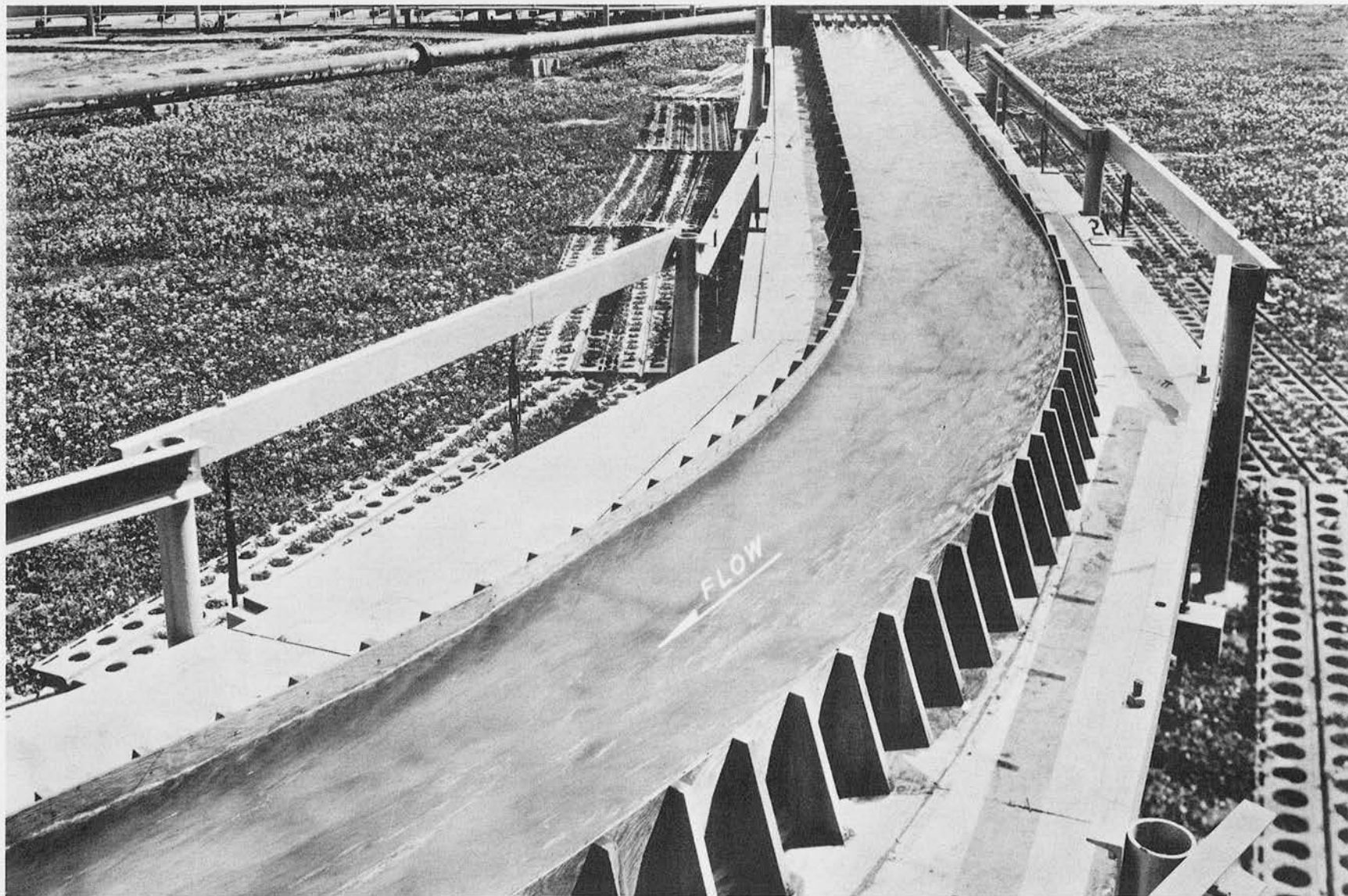


PHOTOGRAPH 9

Original design, junction Tophet Brook
Discharge: Hoosic River 13,000 cfs; Tophet Brook 2,000 cfs



Plan 3 design, main channel. Station 63+00 to station 55+00
Discharge 8,200 cfs



Plan 3 design, main channel. Station 63+00 to station 55+00
Discharge 13,000 cfs



Plan 3 stilling basin
Discharge 8,200 cfs



Plan 3 stilling basin
Discharge 13,000 cfs



Plan 3 design, main channel. Station 47+50 to station 50+00
Discharge 8,200 cfs



PHOTOGRAPH 15

Plan 3 design, main channel. Station 47+50 to station 50+00
Discharge 13,000 cfs



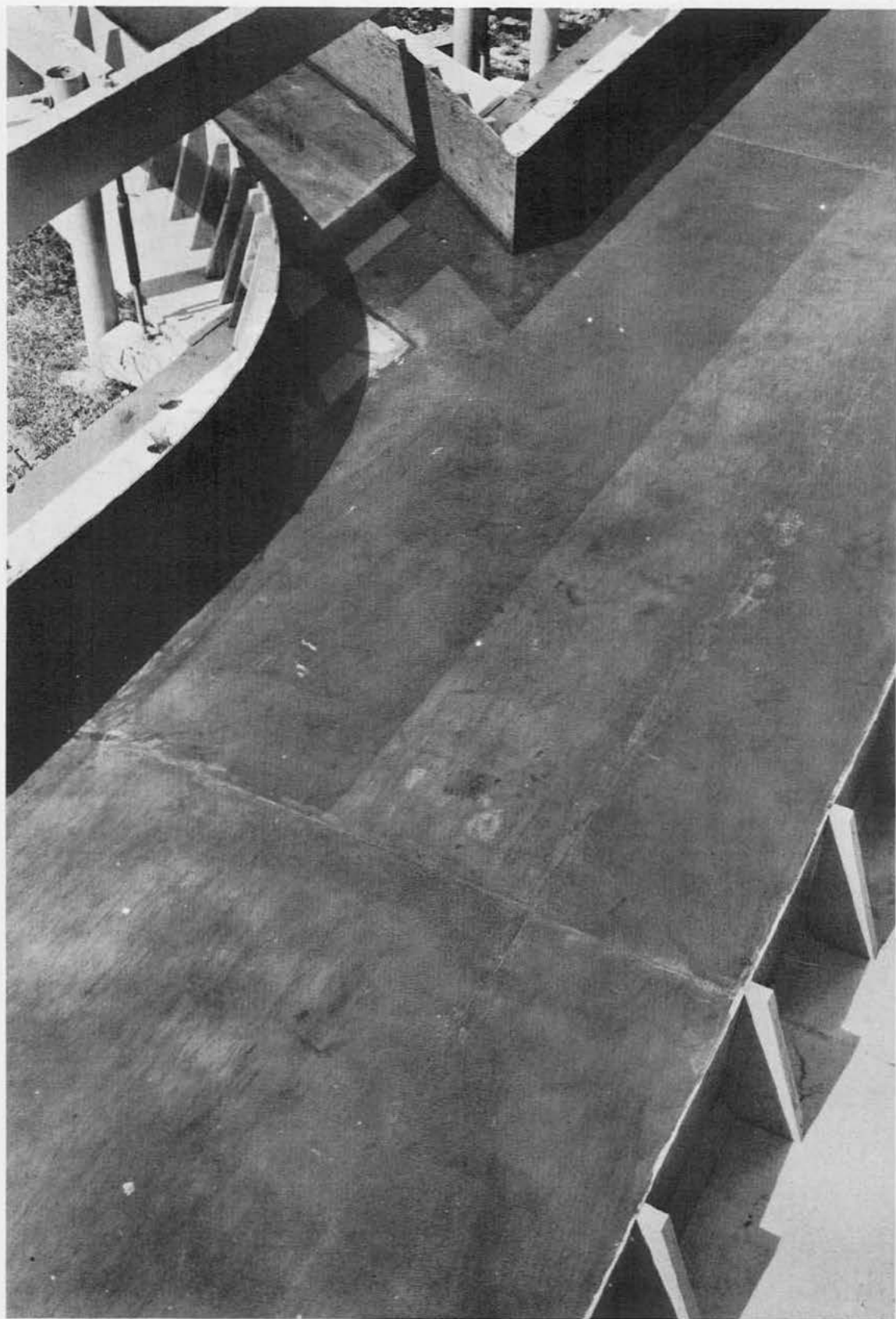
Original design, junction of Tophet Brook with Plan 3 channel
Discharge: Tophet Brook 2,000 cfs; Hoosic River 8,200 cfs



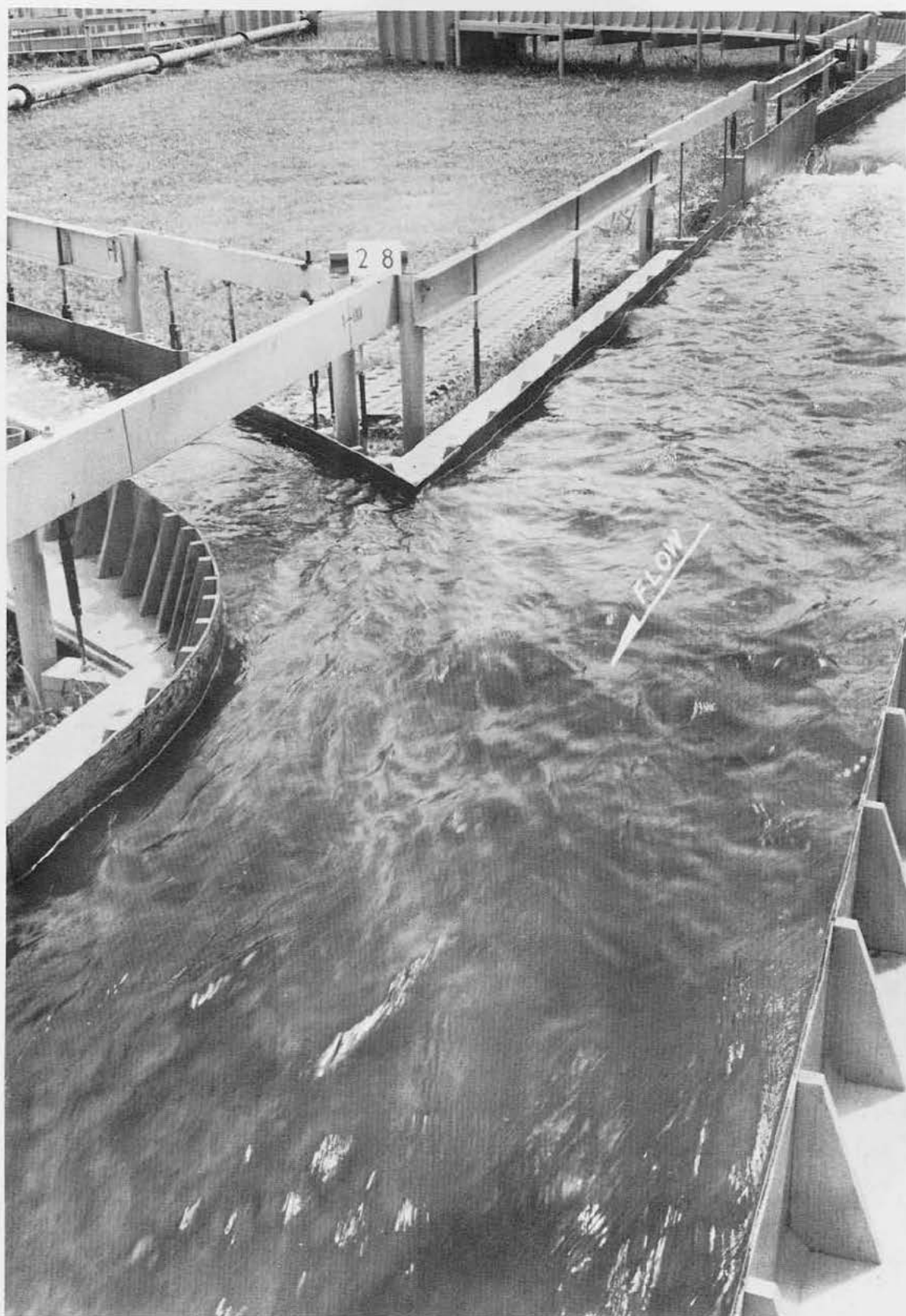
Original design, junction of Tophet Brook with Plan 3 channel
Discharge: Tophet Brook 2,000 cfs; Hoosic River 13,000 cfs



Plan 3 design, overflow weir lower end of model
Discharge: Tophet Brook 2,000 cfs; Hoosic River 8,200 cfs



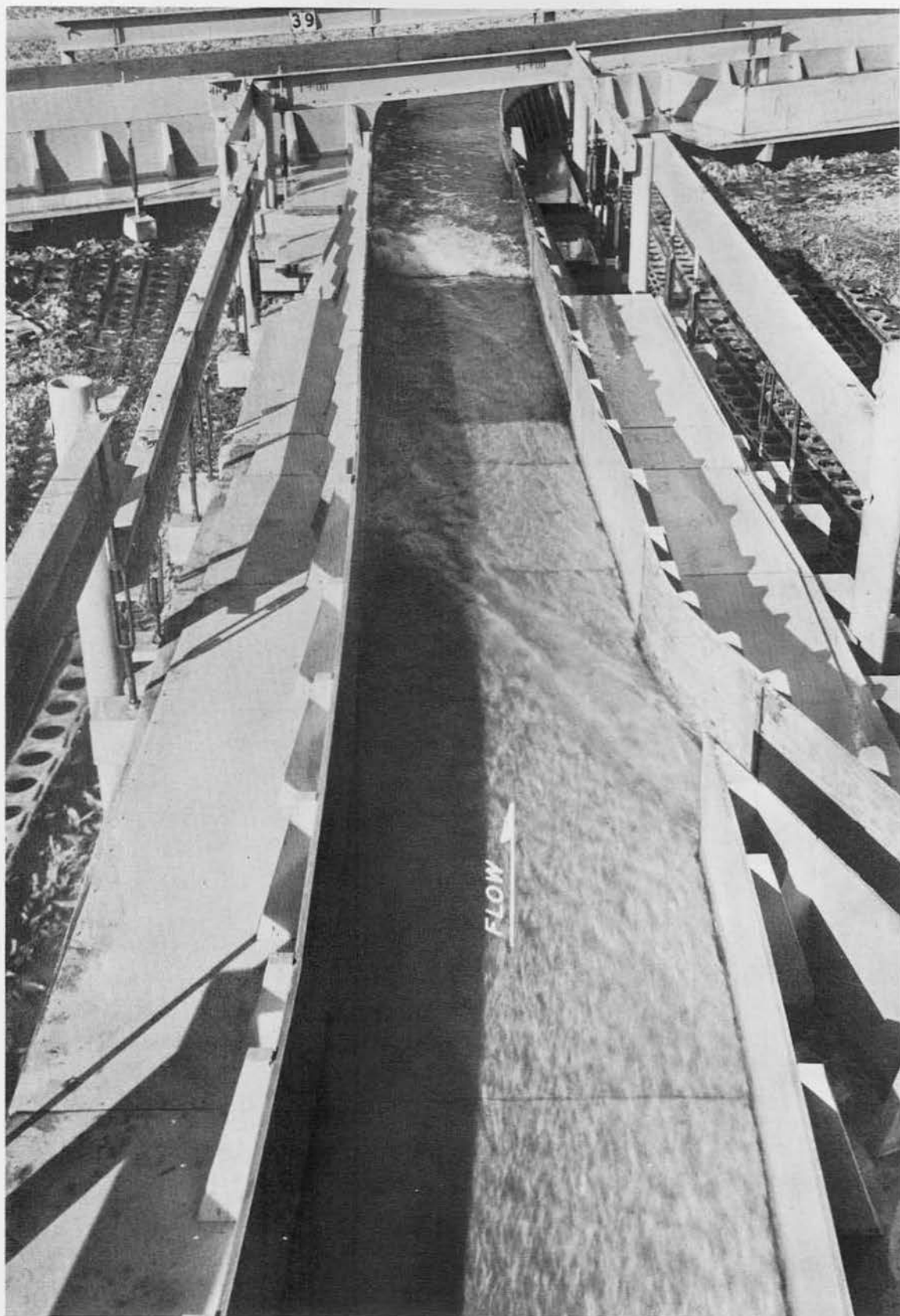
Plan 4, revised junction of Tophet Brook with Plan 3 channel



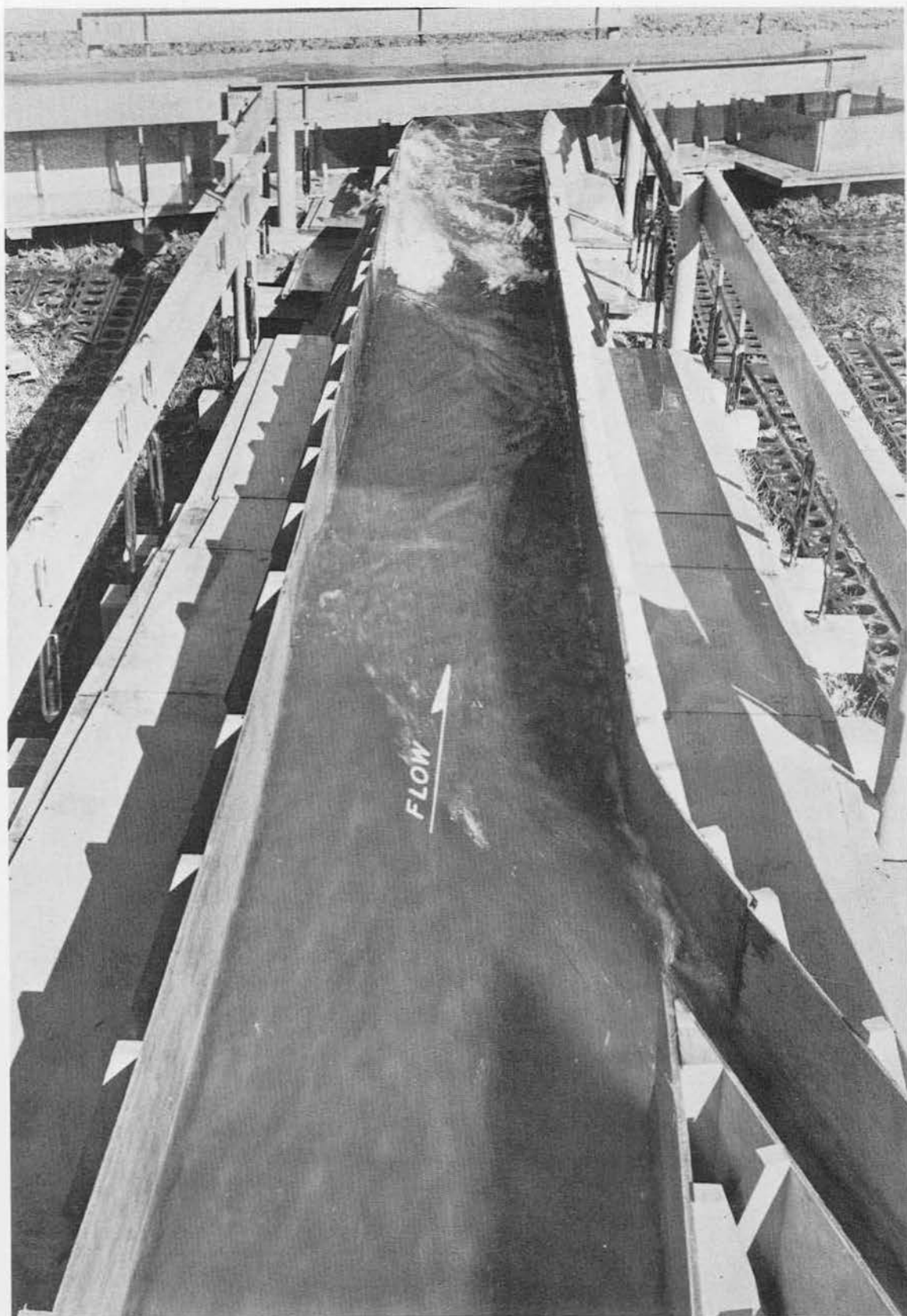
Plan 4, revised junction of Tophet Brook with Plan 3 channel
Discharge: Tophet Brook 2,000 cfs; Hoosic River 8,200 cfs



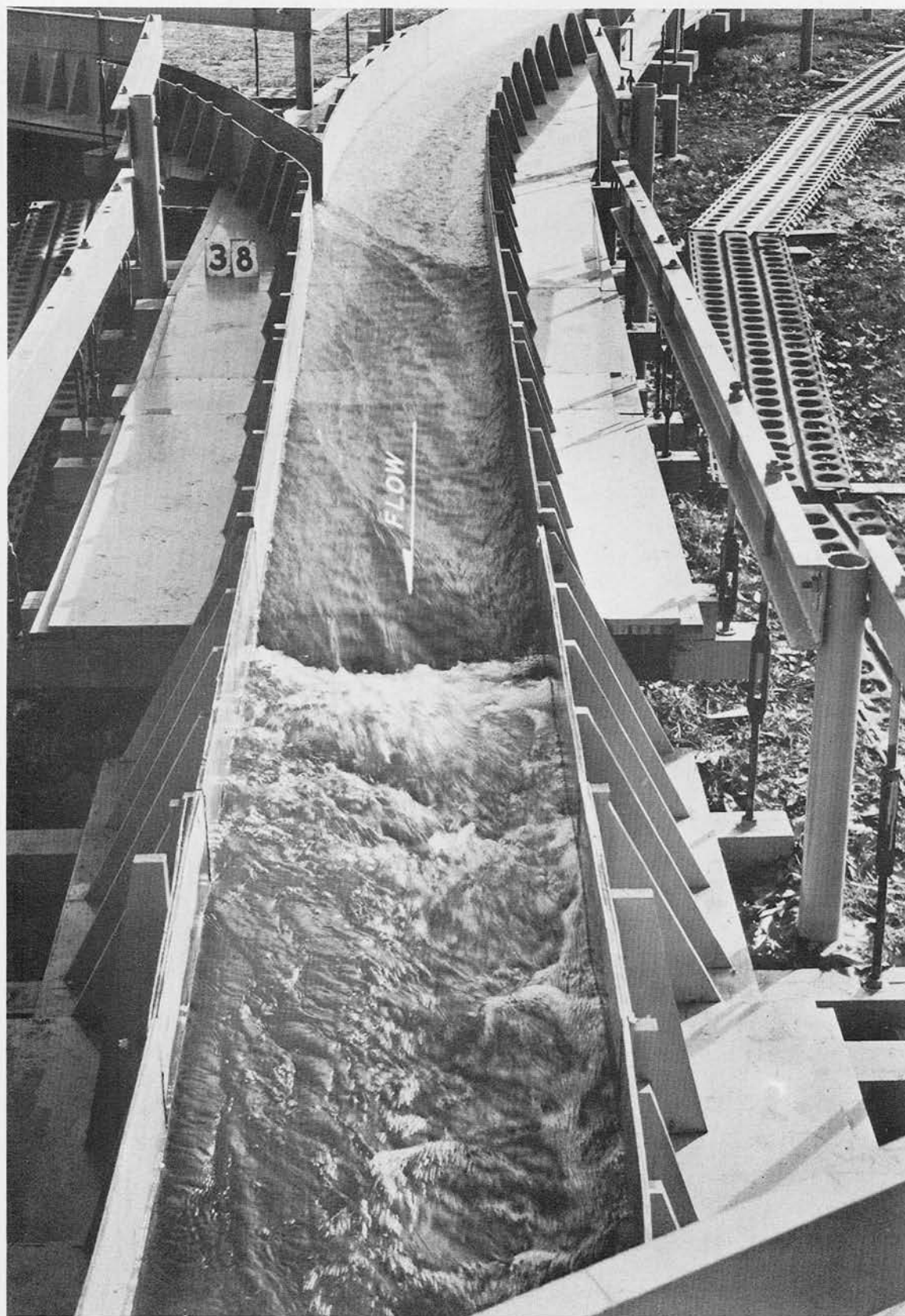
Plan 4, revised junction of Tophet Brook with Plan 3 channel
Discharge: Tophet Brook 2,000 cfs; Hoosic River 13,000 cfs



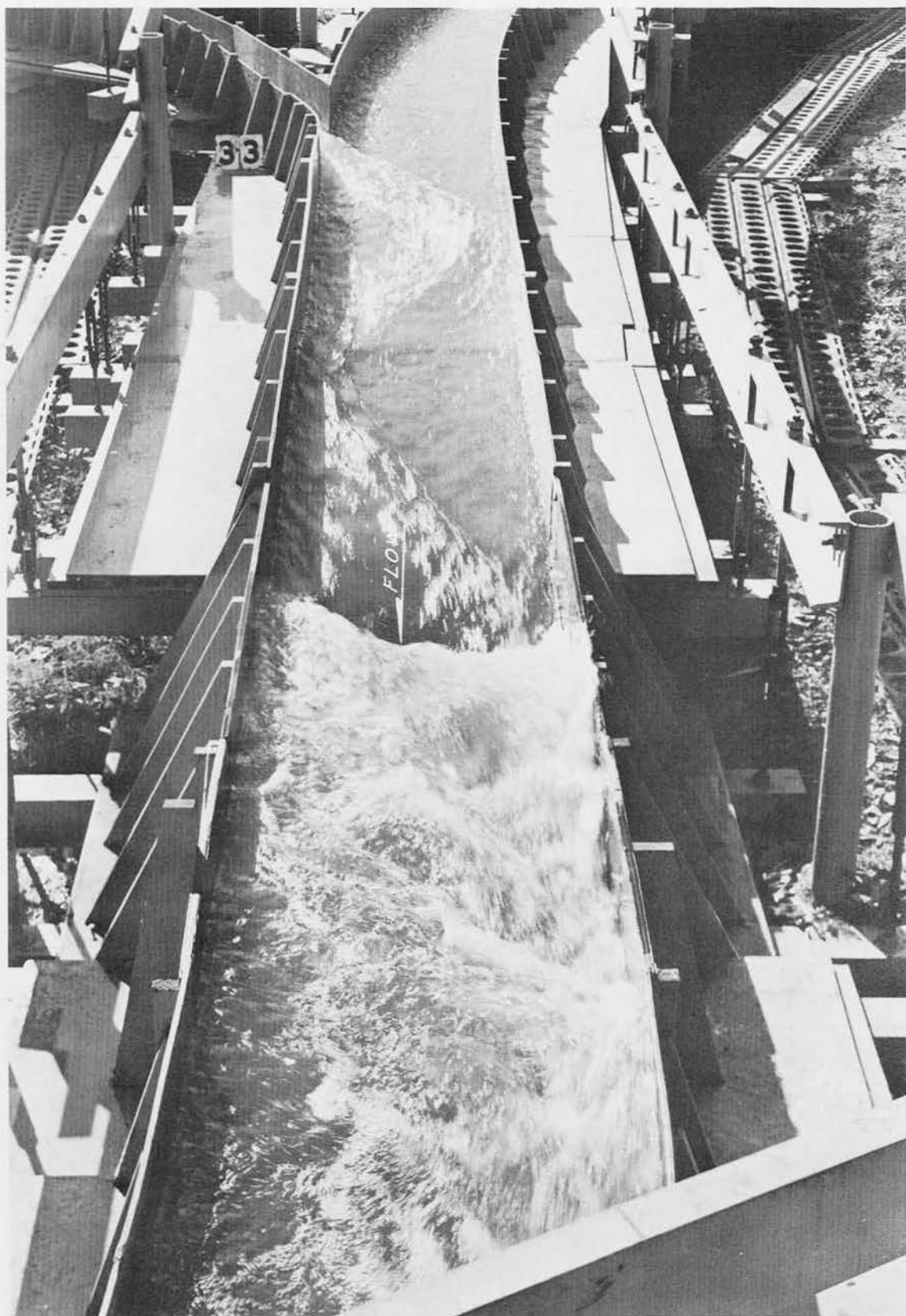
Original design, junction culvert flume with Tophet Brook
Discharge: culvert flume 360 cfs; Tophet Brook 1,640 cfs



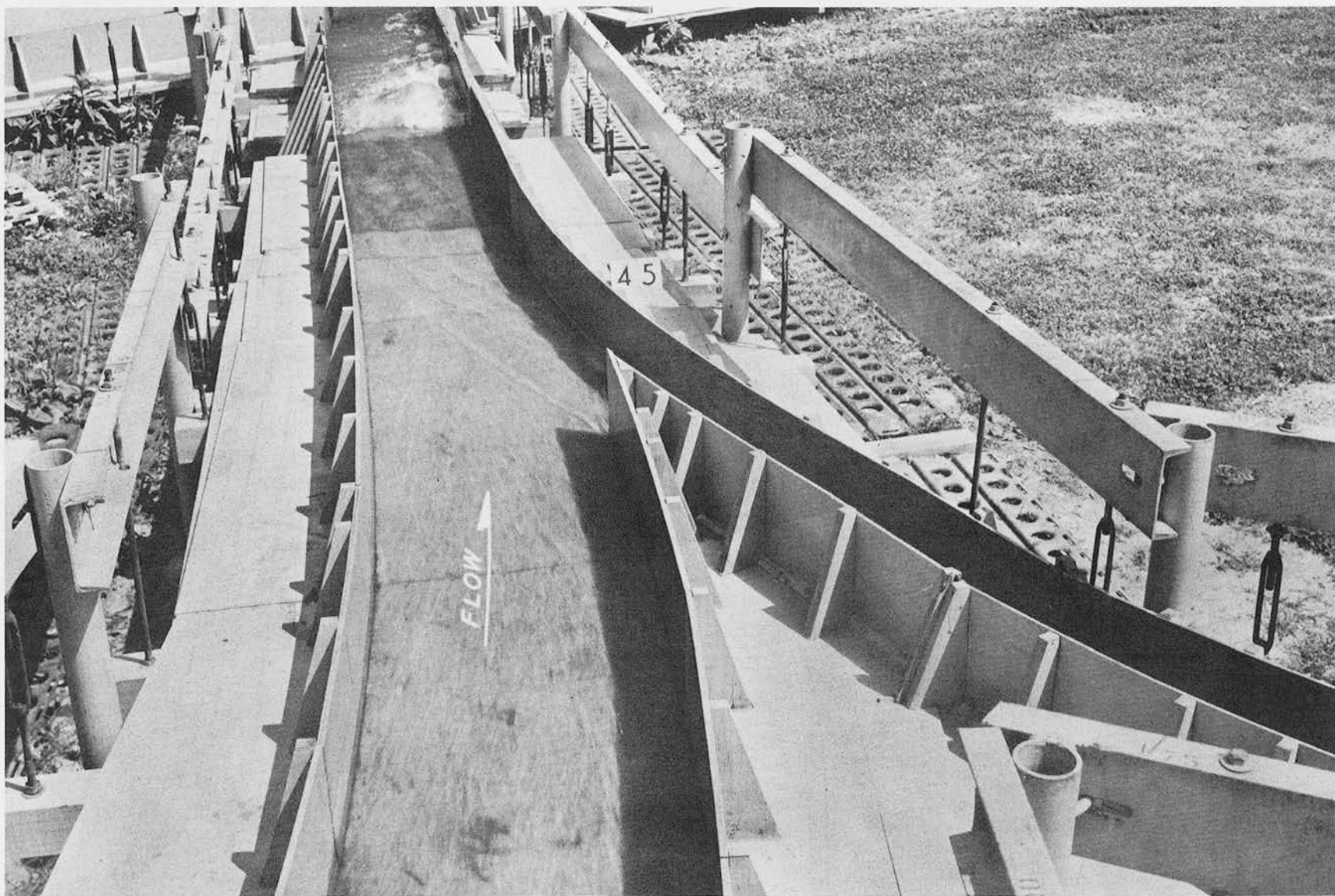
Original design, culvert flume with Tophet Brook
Discharge: culvert flume 900 cfs; Tophet Brook 4,100 cfs



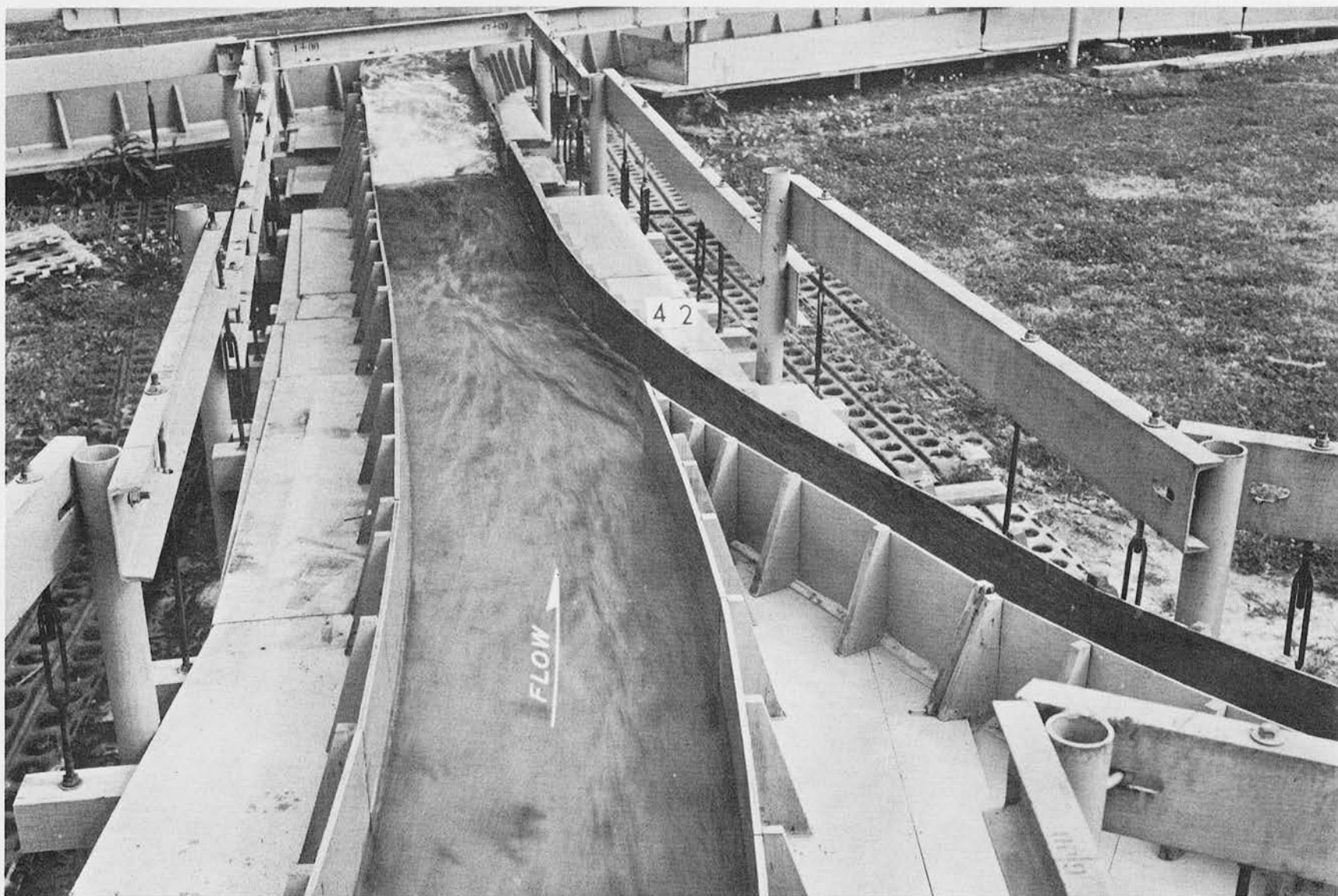
Original design, culvert flume with Tophet Brook
Discharge: culvert flume 360 cfs; Tophet Brook 1,640 cfs



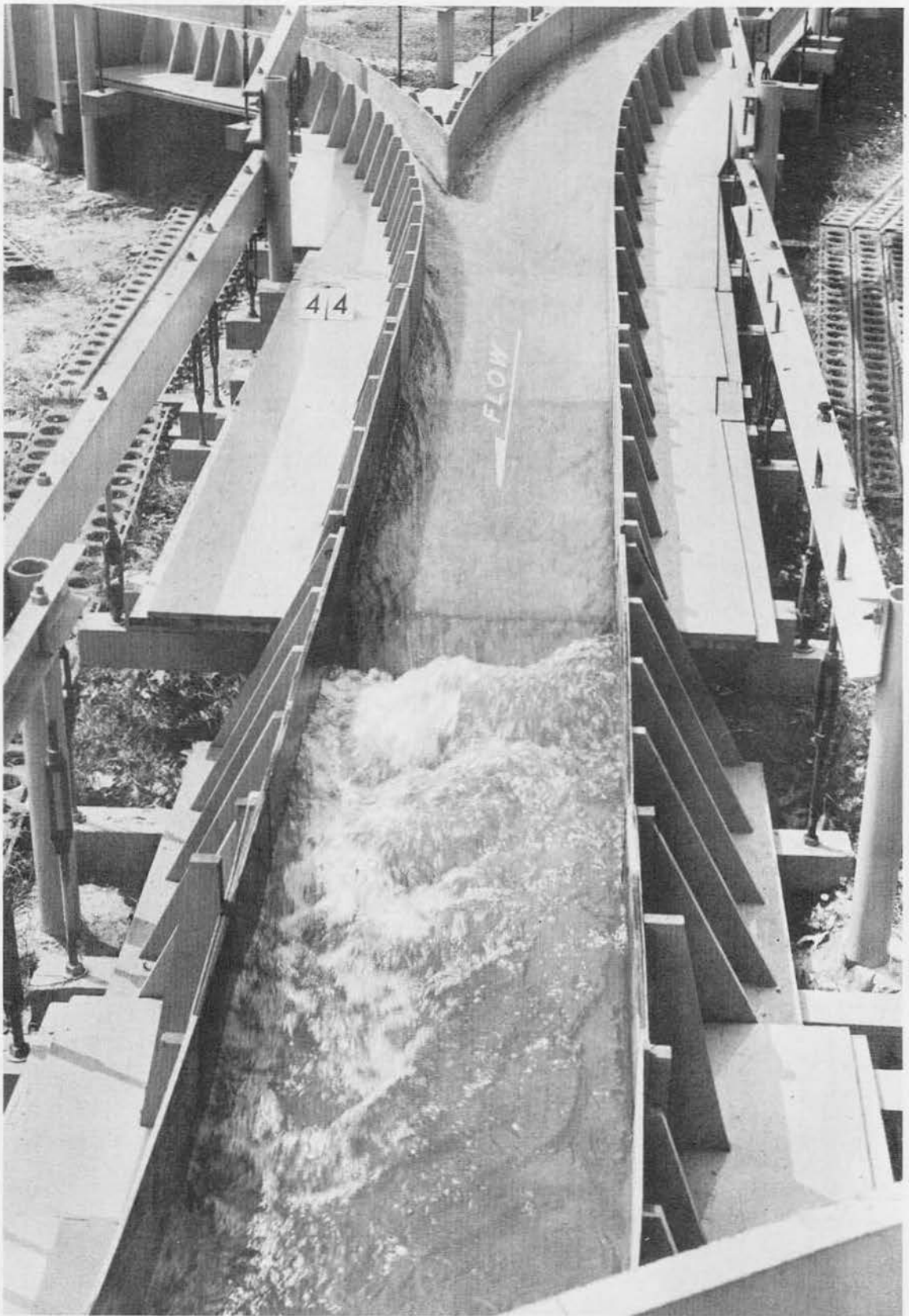
Original design, junction culvert flume with Tophet Brook
Discharge: culvert flume 900 cfs; Tophet Brook 4,100 cfs



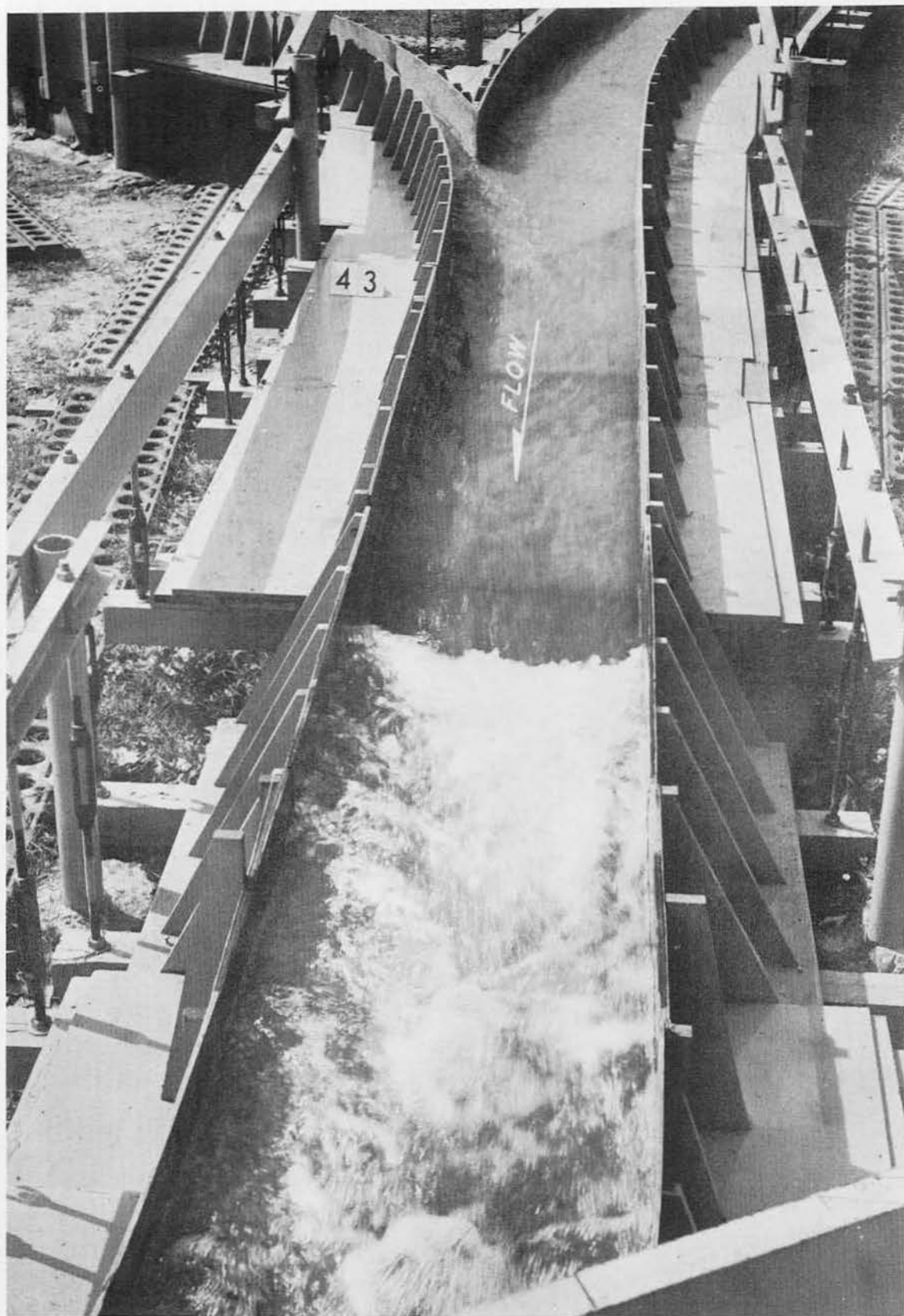
Revised design, junction culvert flume with Tophet Brook
Discharge: culvert flume 360 cfs; Tophet Brook 1,640 cfs



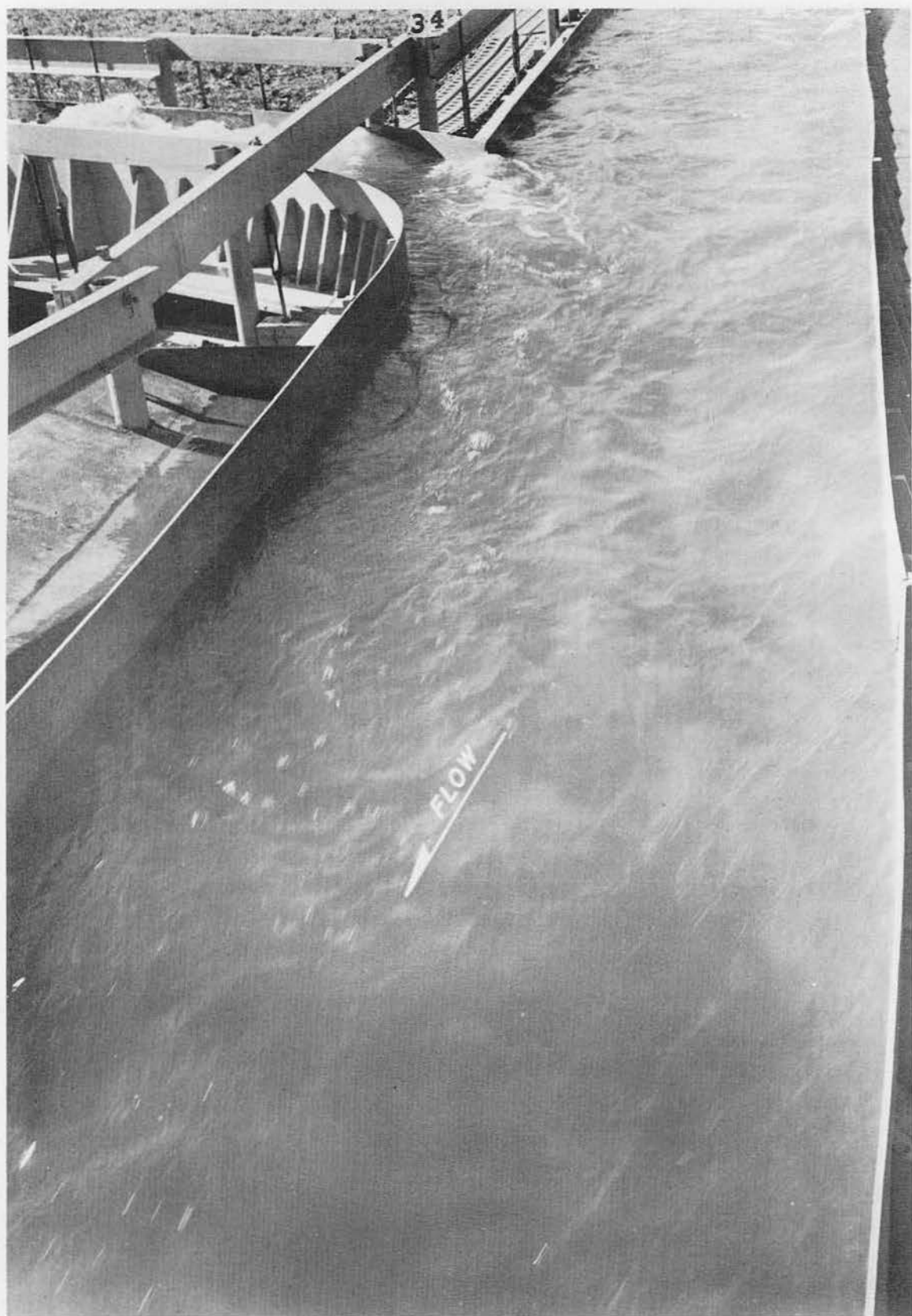
Revised design, junction culvert flume with Tophet Brook
Discharge: culvert flume 900 cfs; Tophet Brook 4,100 cfs



Revised design, junction culvert flume with Tophet Brook
Discharge: culvert flume 360 cfs; Tophet Brook 1,640 cfs

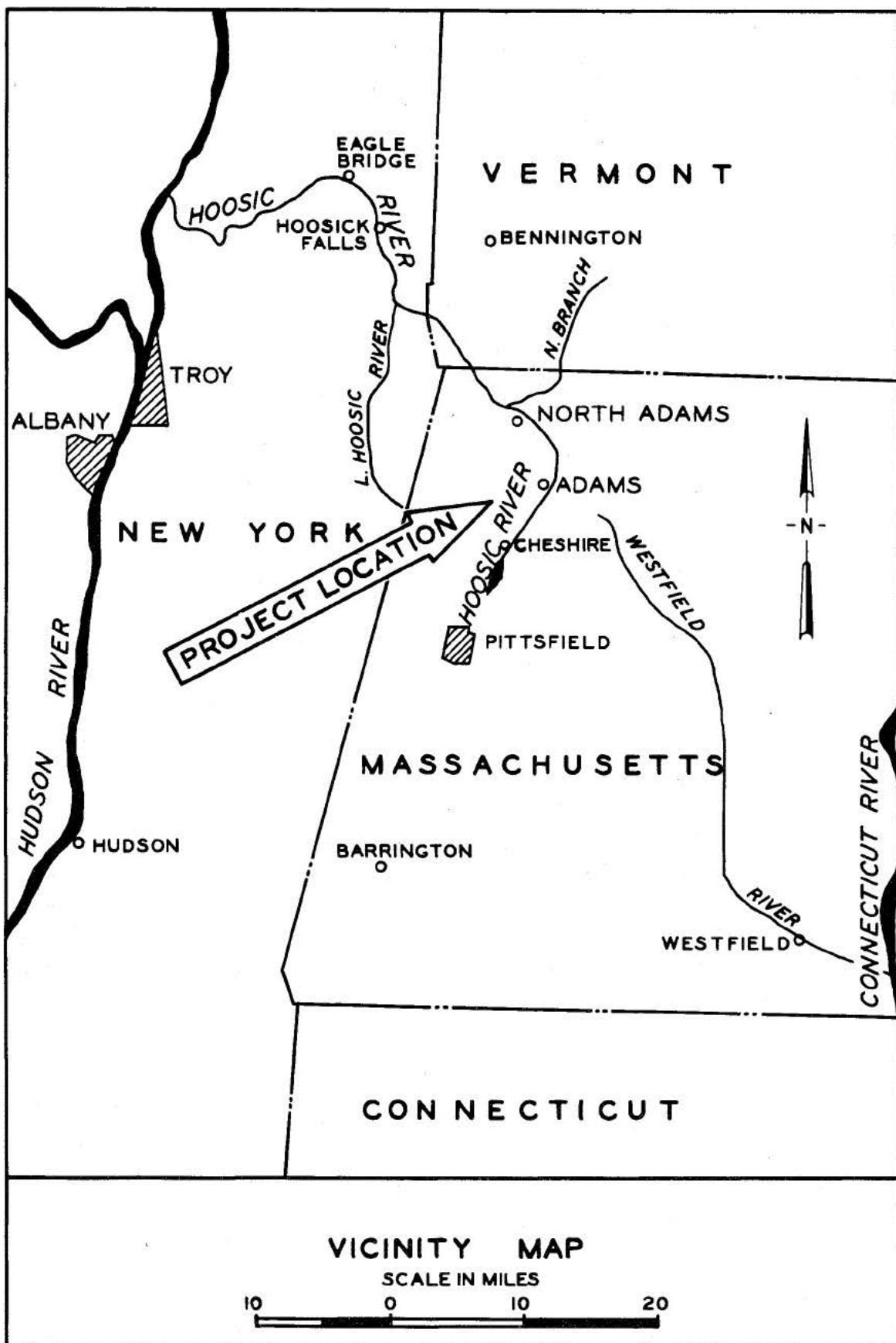


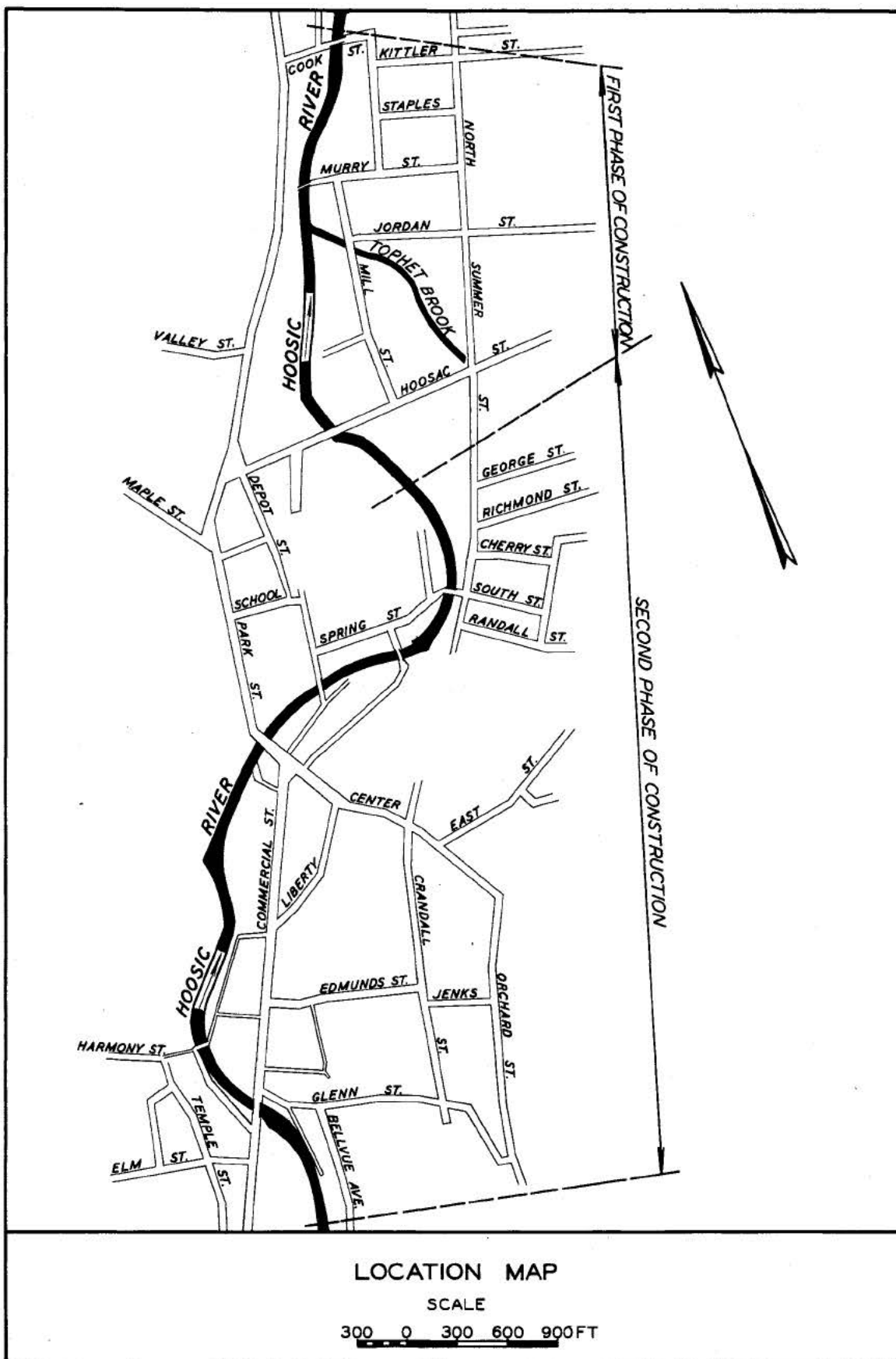
Revised design, junction culvert flume with Tophet Brook. Discharge:
culvert flume 900 cfs; Tophet Brook 4,100 cfs

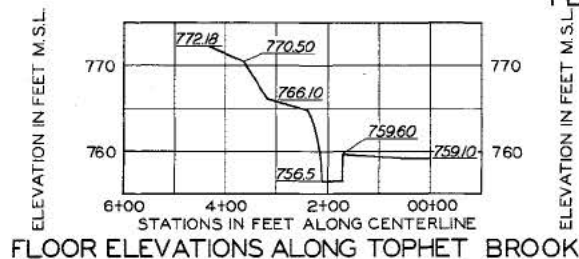
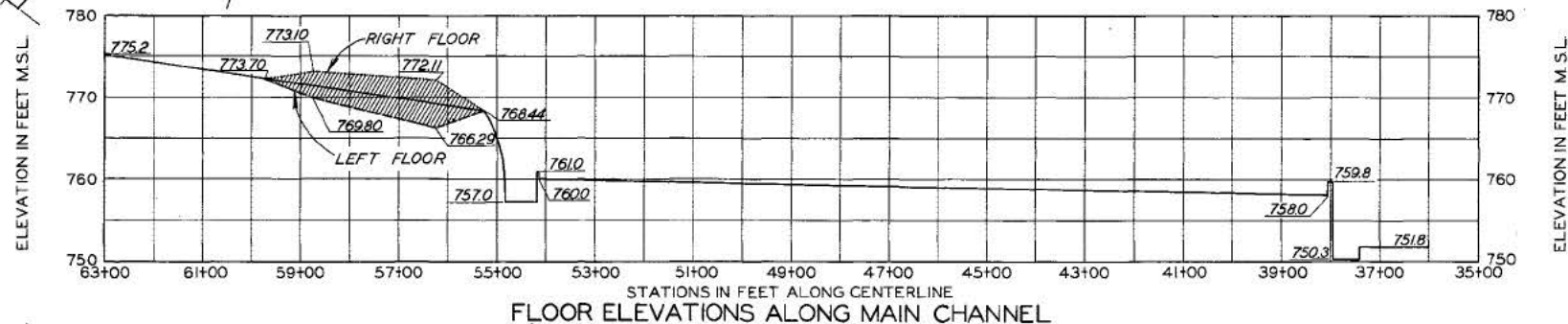
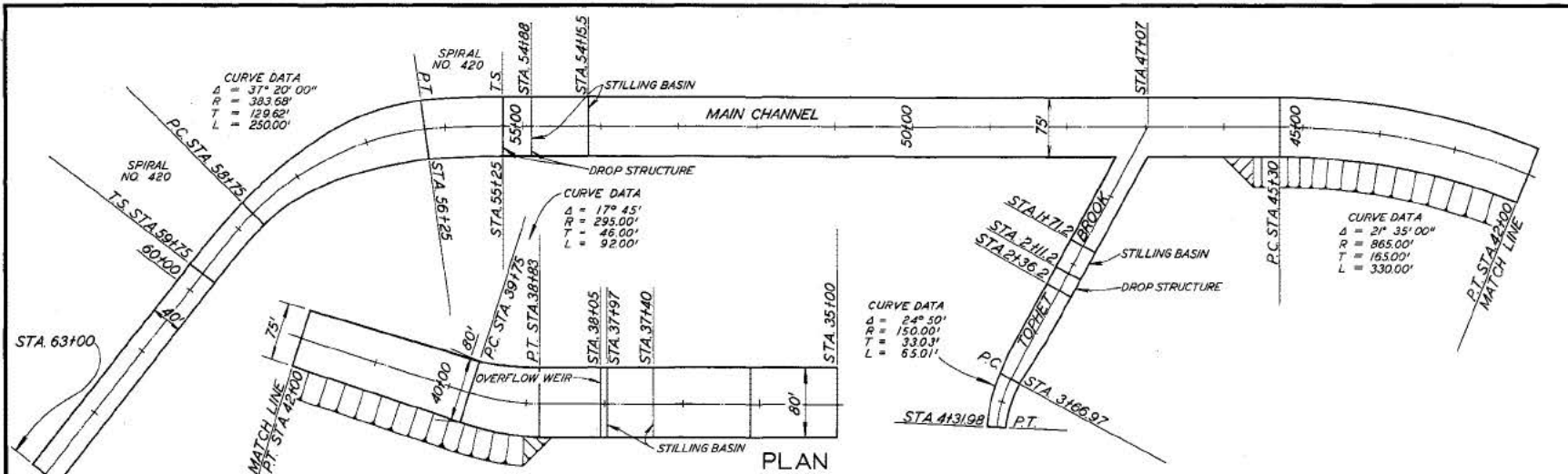


Recommended design, junction Tophet Brook with Hoosic River
Discharge: Tophet Brook 5,000 cfs; Hoosic River 13,000 cfs

PLATES



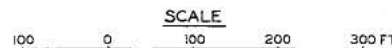




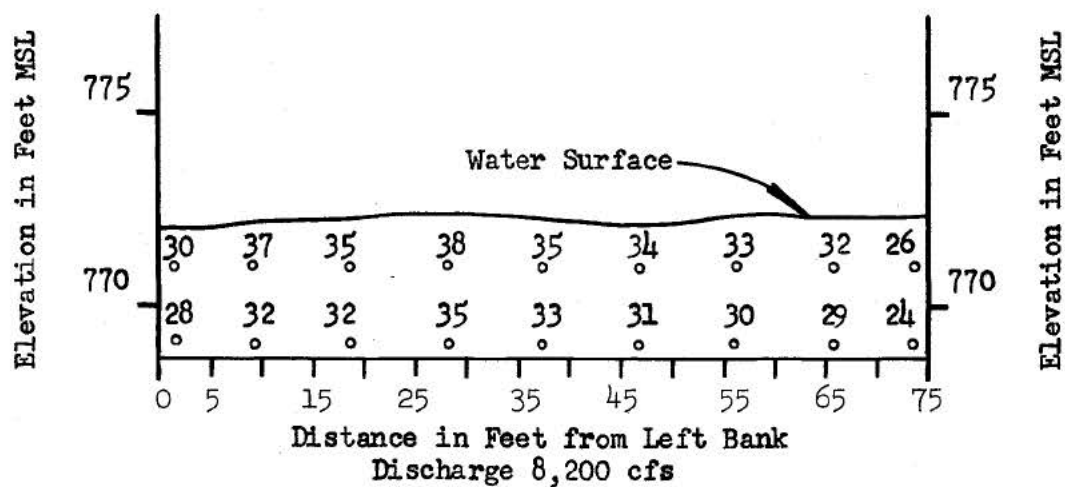
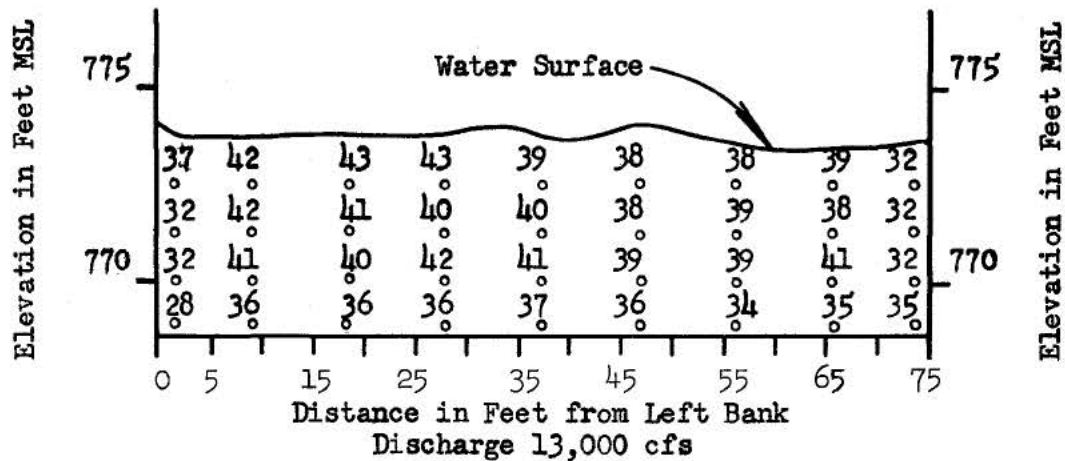
SPIRAL DATA

SPIRAL NO	L_s	Δ_s	U	V
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L_s LENGTH OF SPIRAL
 Δ_s DEFLECTION OF SPIRAL
 U LONG TANGENT LENGTH
 V SHORT TANGENT LENGTH

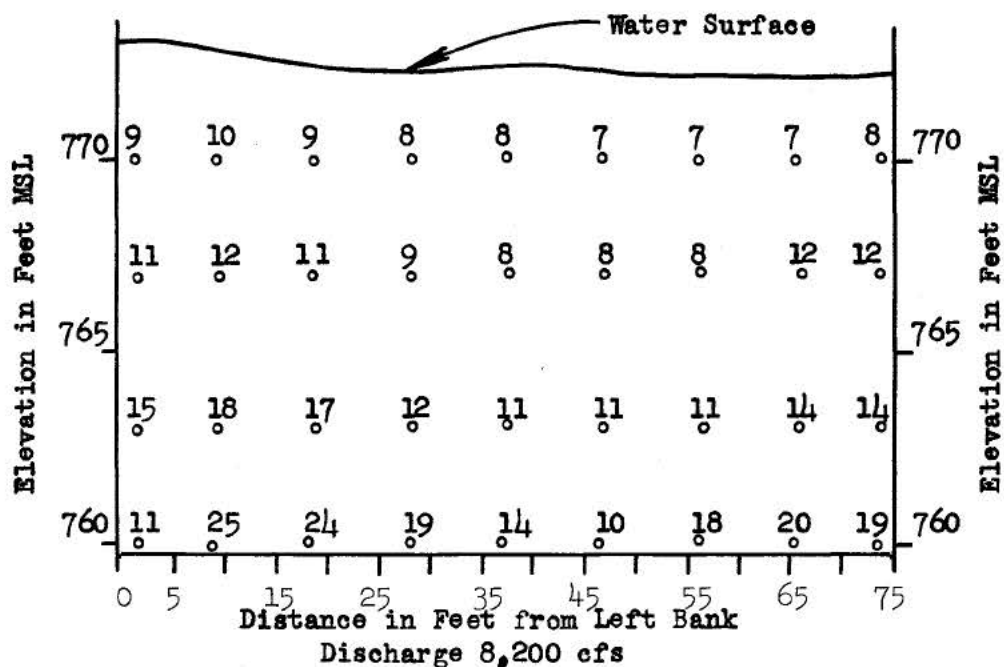
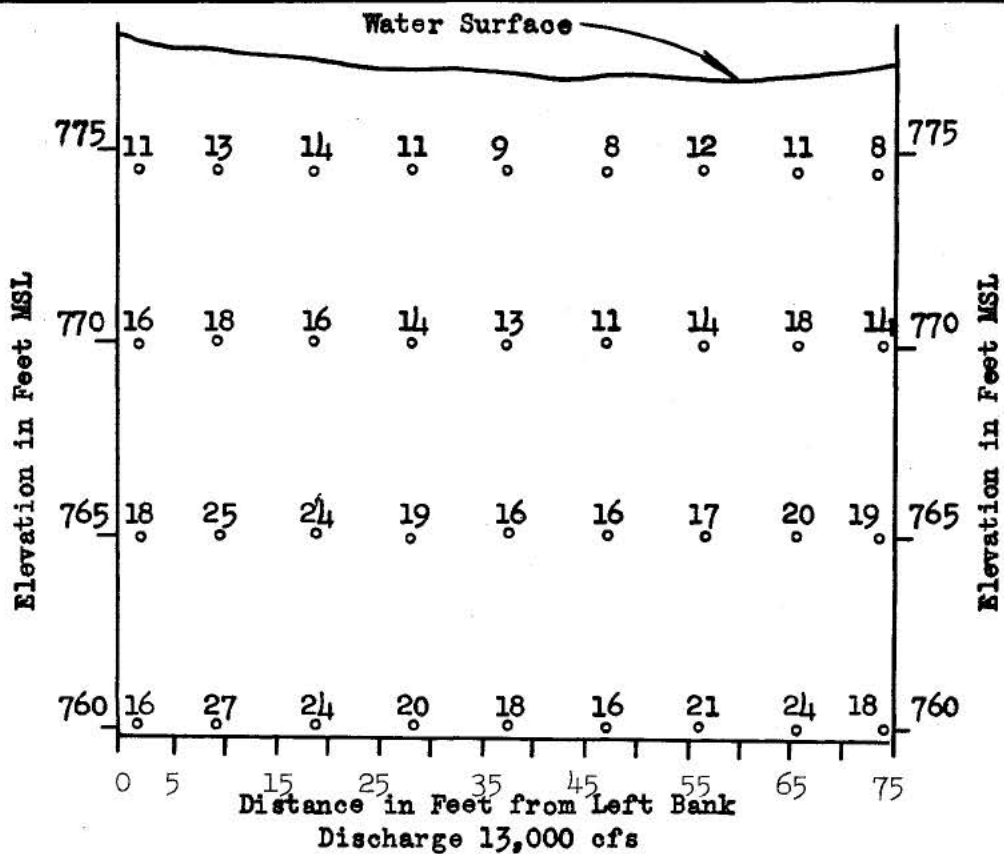


HOOSIC RIVER BASIN
 ADAMS FLOOD CONTROL PROJECT
 ORIGINAL DESIGN



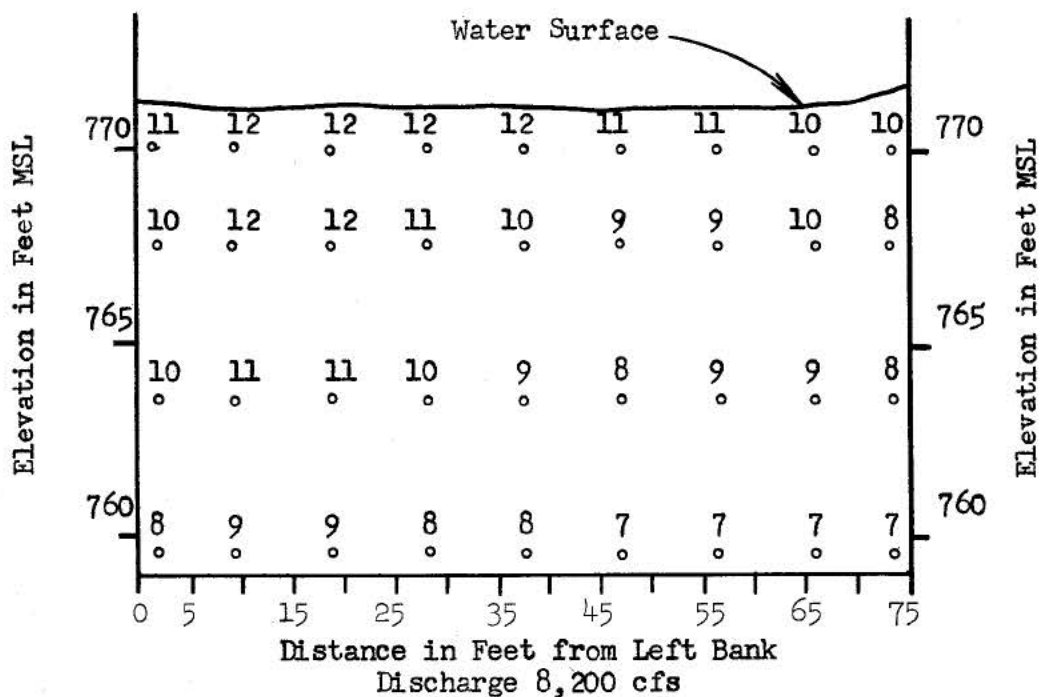
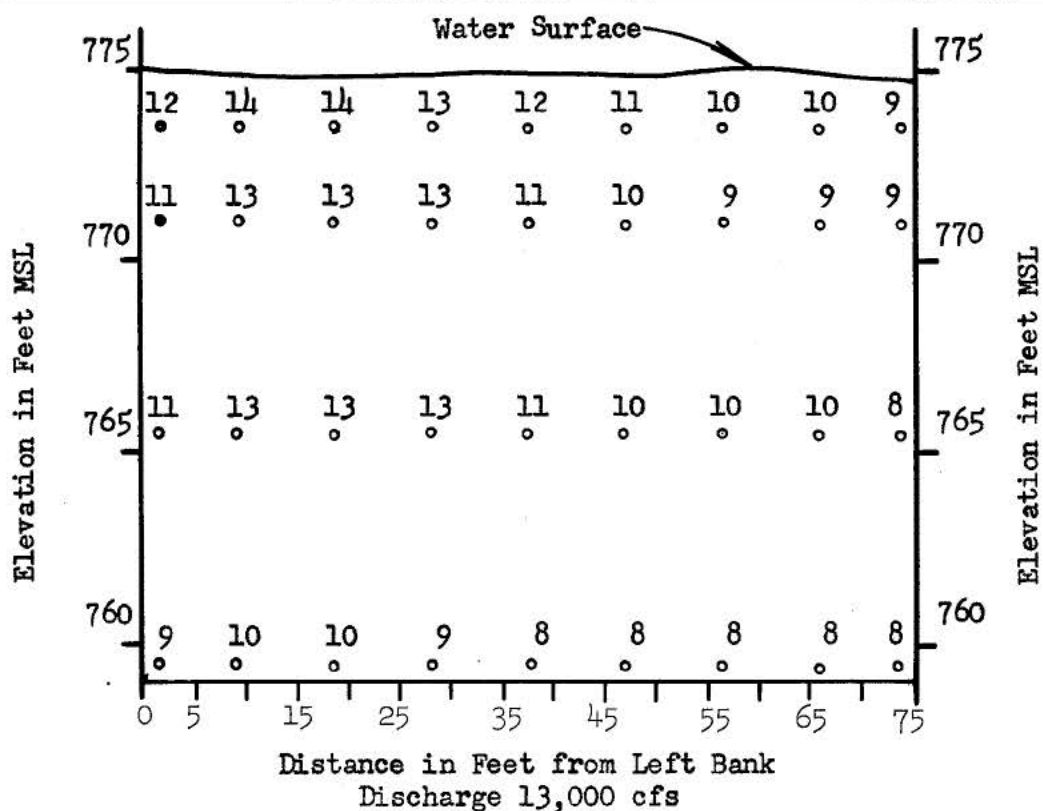
NOTE: Velocities are in feet per second in prototype.

VELOCITIES
HOOSIC RIVER
RECOMMENDED DESIGN
STATION 51 + 50



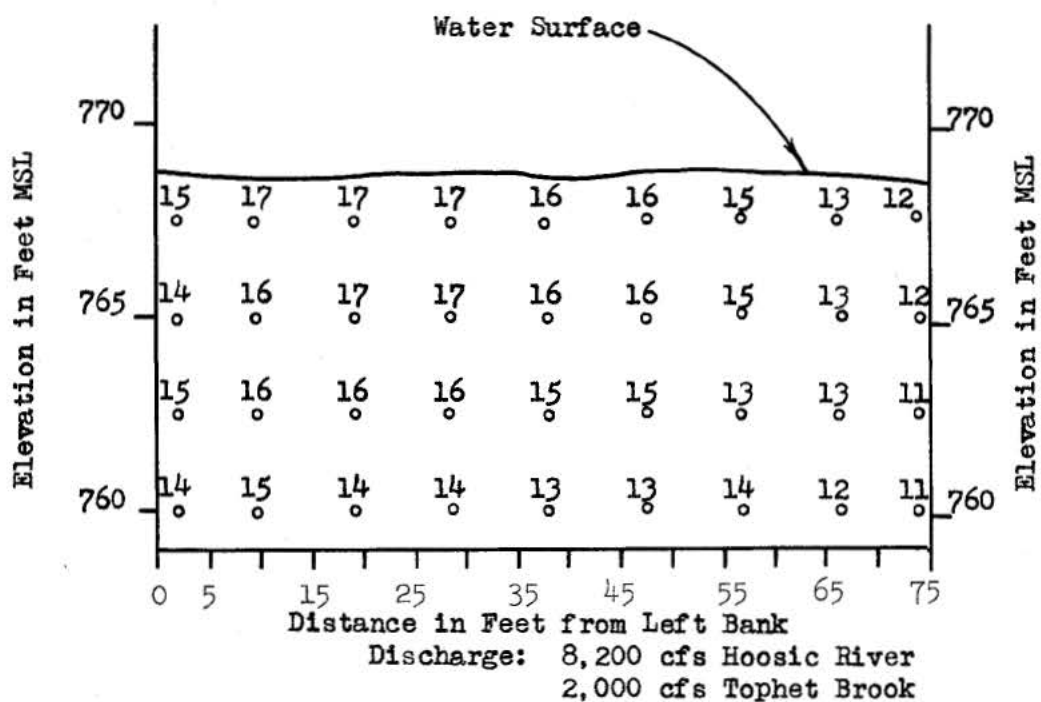
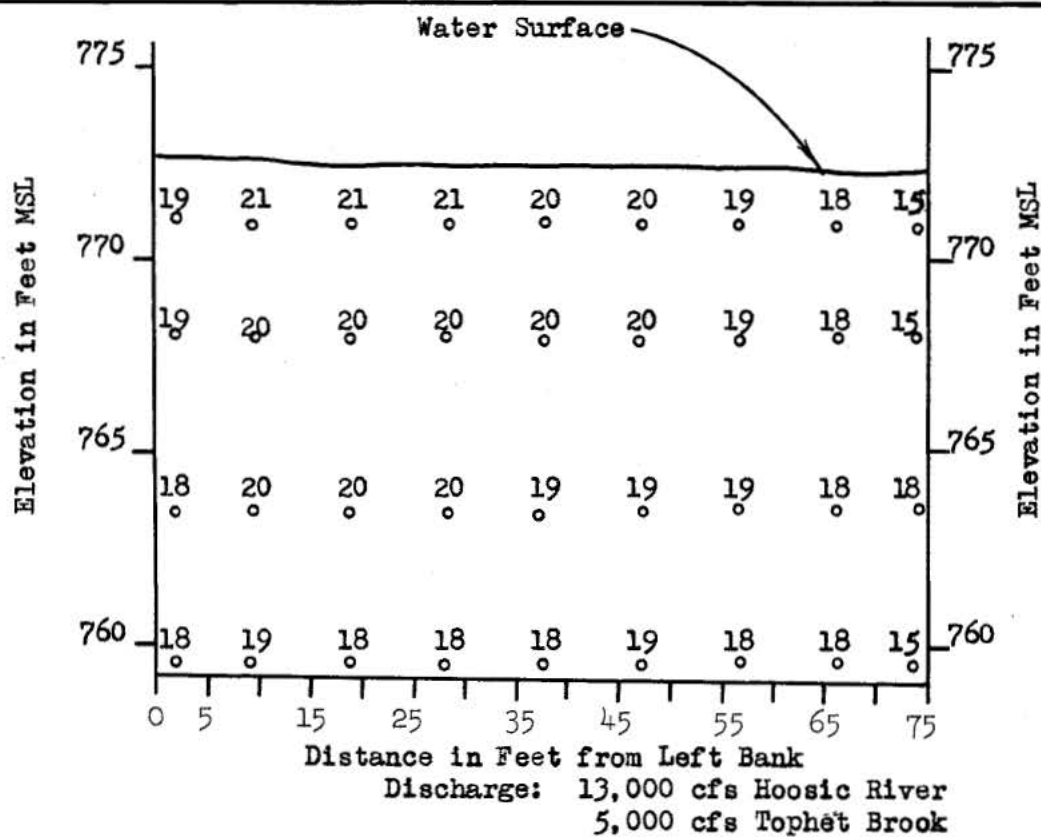
NOTE: Velocities are in feet per second in prototype.

VELOCITIES
HOOSIC RIVER
RECOMMENDED DESIGN
STATION 50 + 00



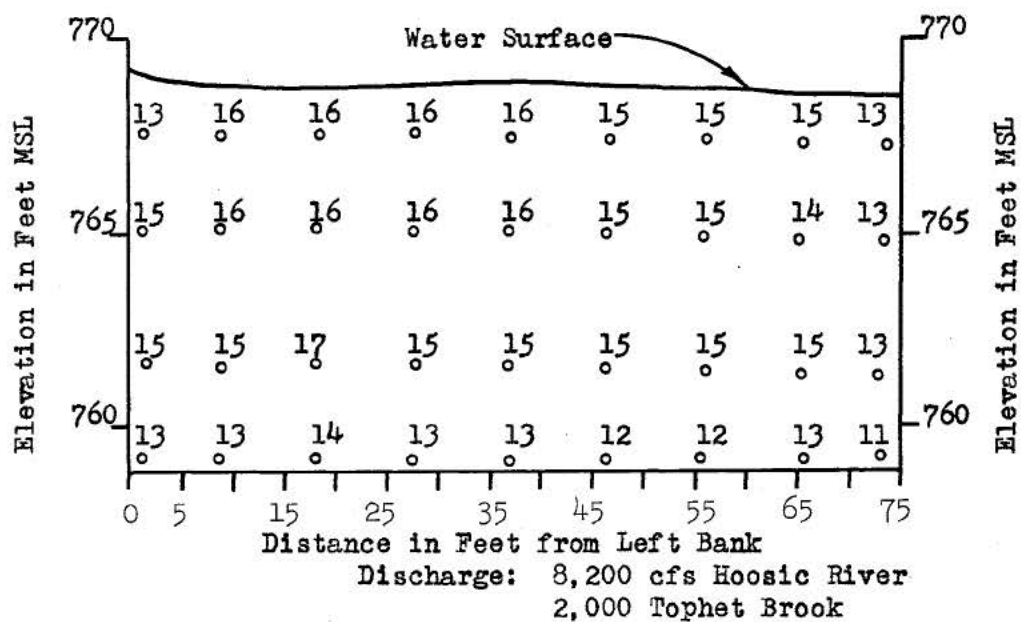
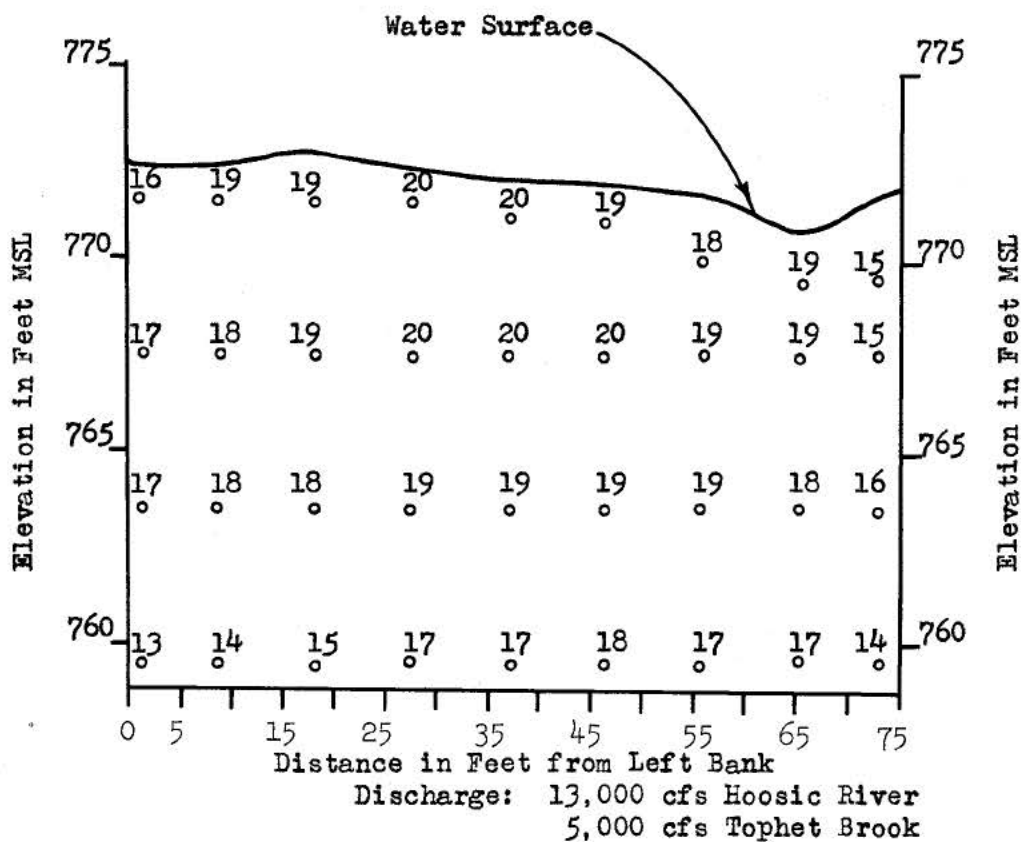
NOTE: Velocities are in feet per second in prototype.

VELOCITIES
HOOSIC RIVER
RECOMMENDED DESIGN
STATION 47 + 75



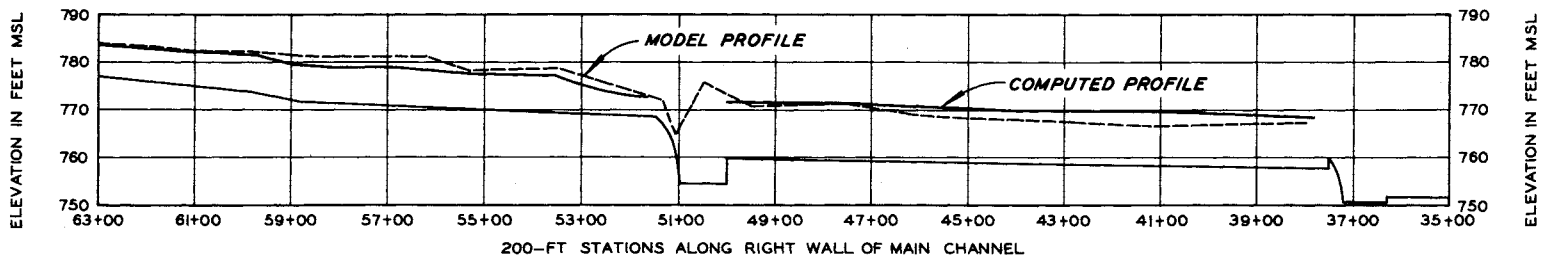
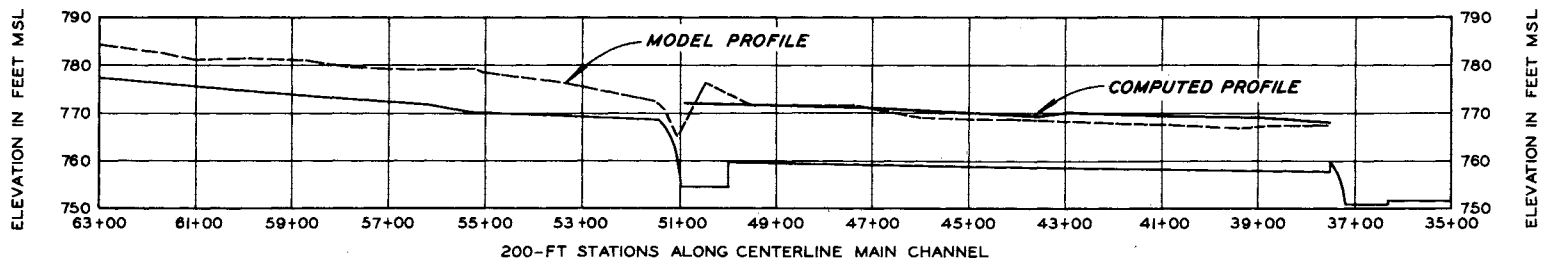
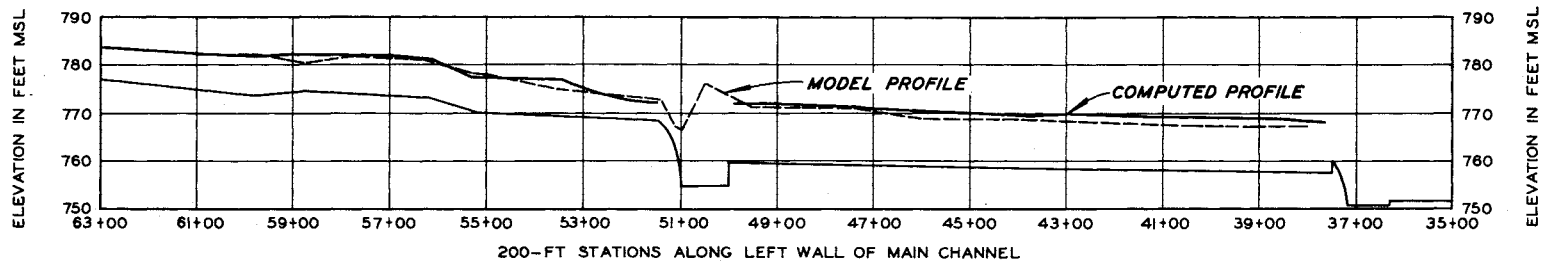
NOTE: Velocities are in feet per second in prototype.

VELOCITIES
HOOSIC RIVER
RECOMMENDED DESIGN
STATION 46 + 00



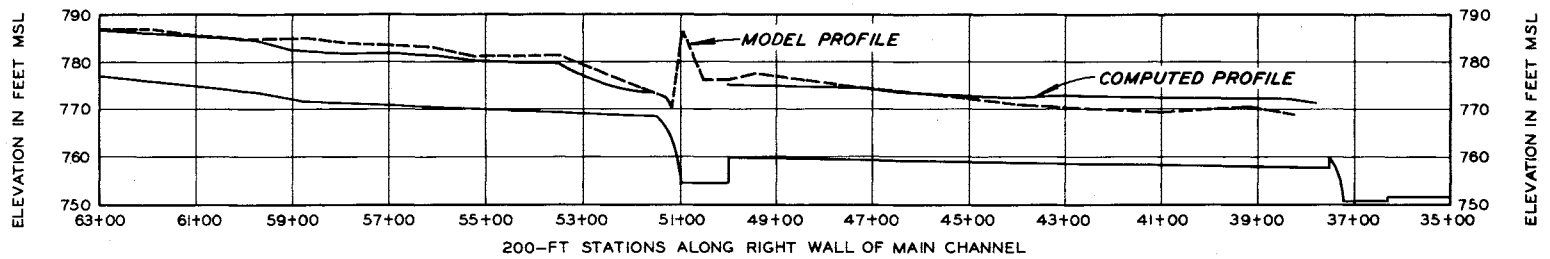
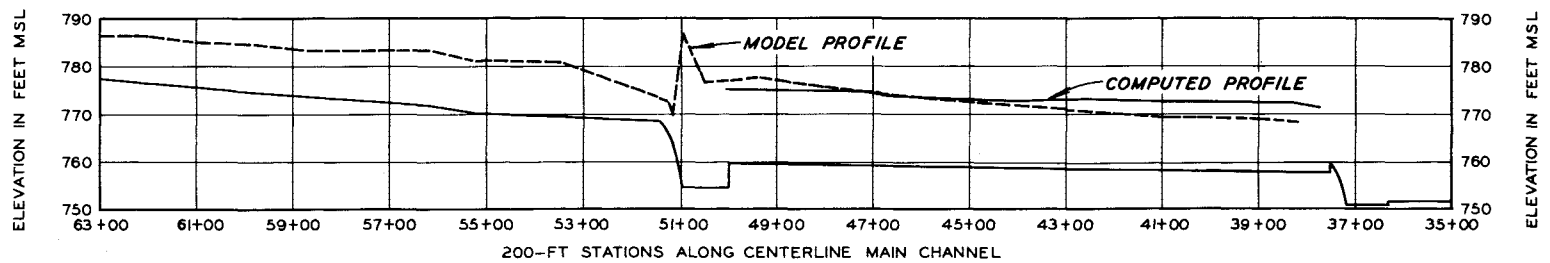
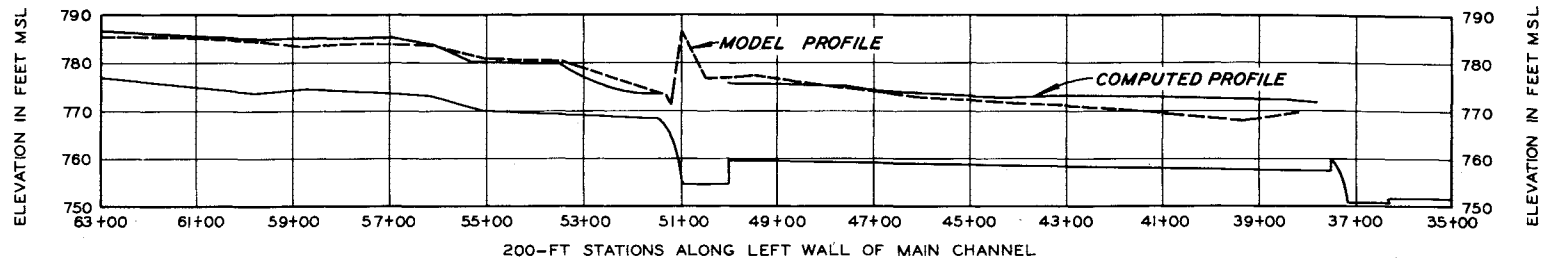
NOTE: Velocities are in feet
per second in prototype.

VELOCITIES
HOOSIC RIVER
RECOMMENDED DESIGN
STATION 44 + 50



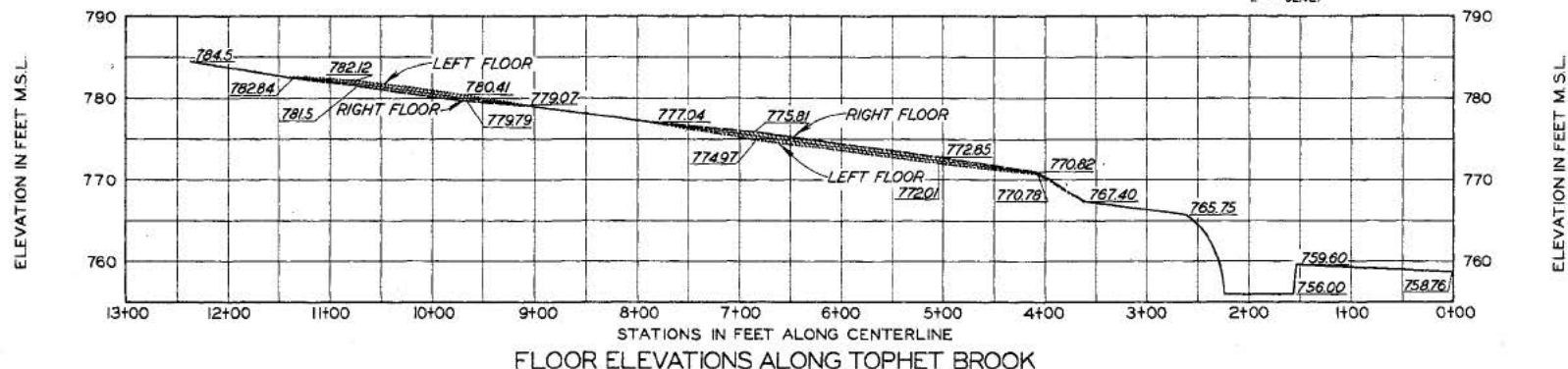
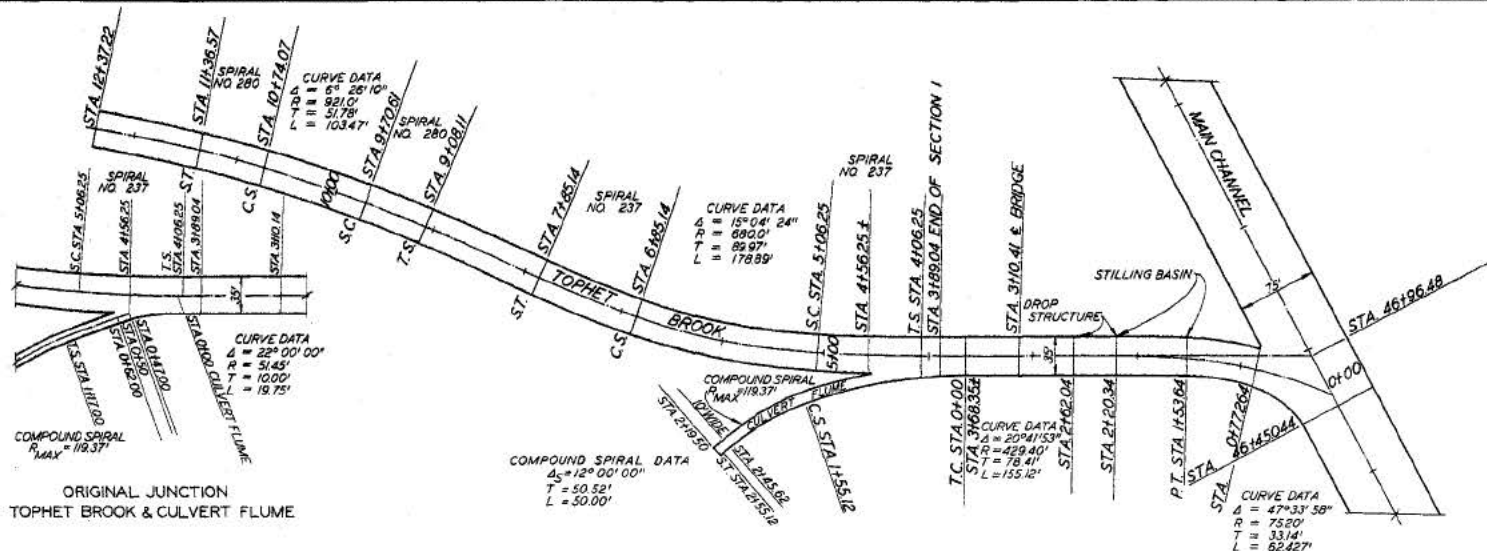
NOTE: TAILWATER CONTROLLED BY ELEVATION OF OVERFLOW WEIR.
DISCHARGE OF 8,200 CFS IN HOOSIC RIVER SUPPLEMENTED BY
DISCHARGE OF 2,000 CFS FROM TOPHET BROOK.

WATER-SURFACE PROFILES
RECOMMENDED DESIGN
DISCHARGE 10,200 CFS



NOTE: TAILWATER CONTROLLED BY ELEVATION OF OVERFLOW WEIR.
DISCHARGE OF 13,000 CFS IN HOOSIC RIVER SUPPLEMENTED BY
DISCHARGE OF 5,000 CFS FROM TOPHET BROOK.

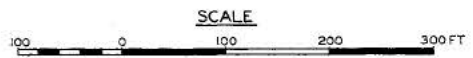
WATER-SURFACE PROFILES
RECOMMENDED DESIGN
DISCHARGE 18,000 CFS



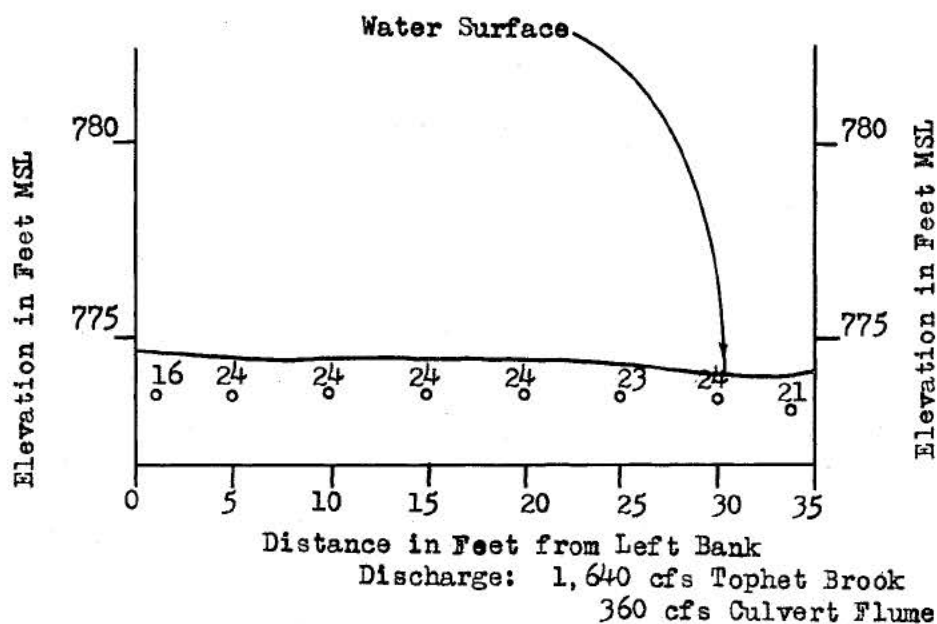
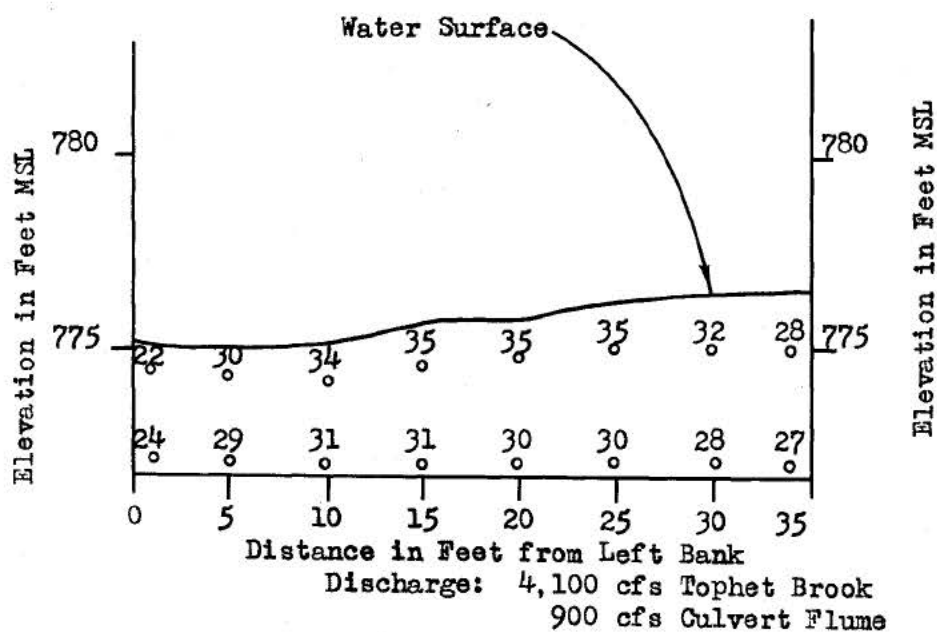
SPIRAL DATA

SPIRAL NO	L _S	Δ _S	U	V
237	100.00'	4° 12' 48"	66.43'	33.61'
280	62.50'	1° 58' 40"	41.25'	21.25'

L_S LENGTH OF SPIRAL
 Δ_S DEFLECTION OF SPIRAL
 U LONG TANGENT LENGTH
 V SHORT TANGENT LENGTH

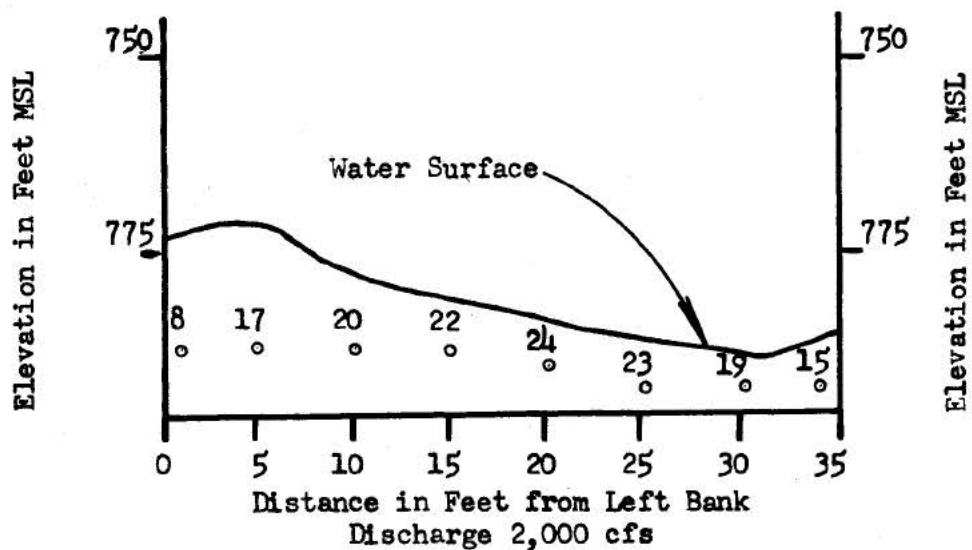
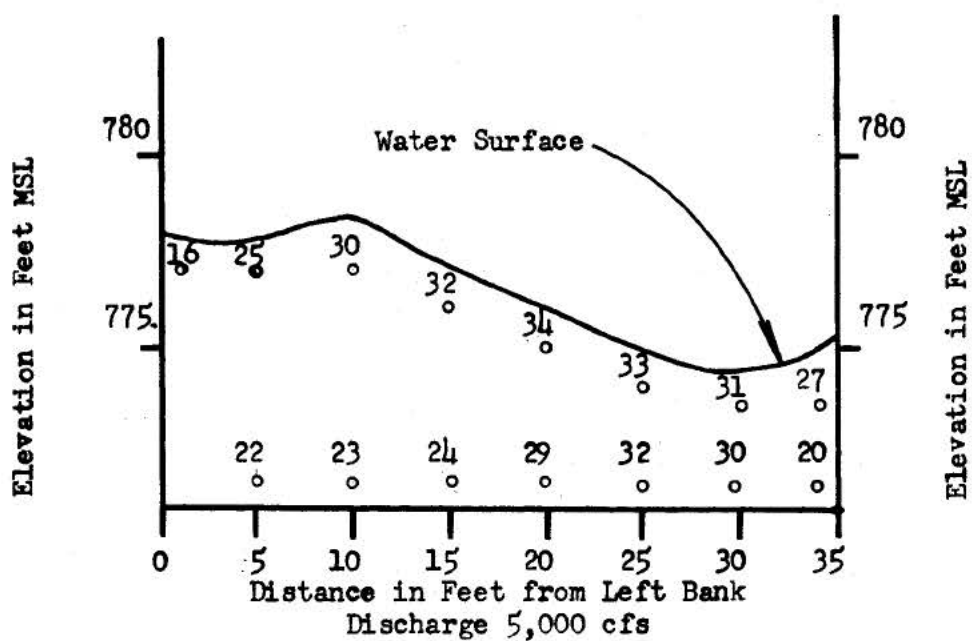


HOOSIC RIVER BASIN
ADAMS FLOOD CONTROL PROJECT
TOPHET BROOK AND CULVERT FLUME
RECOMMENDED DESIGN



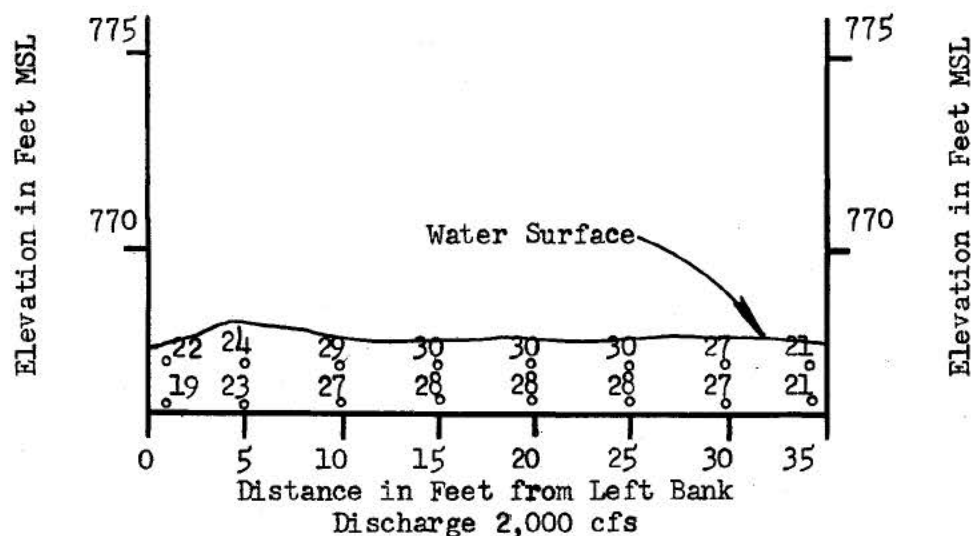
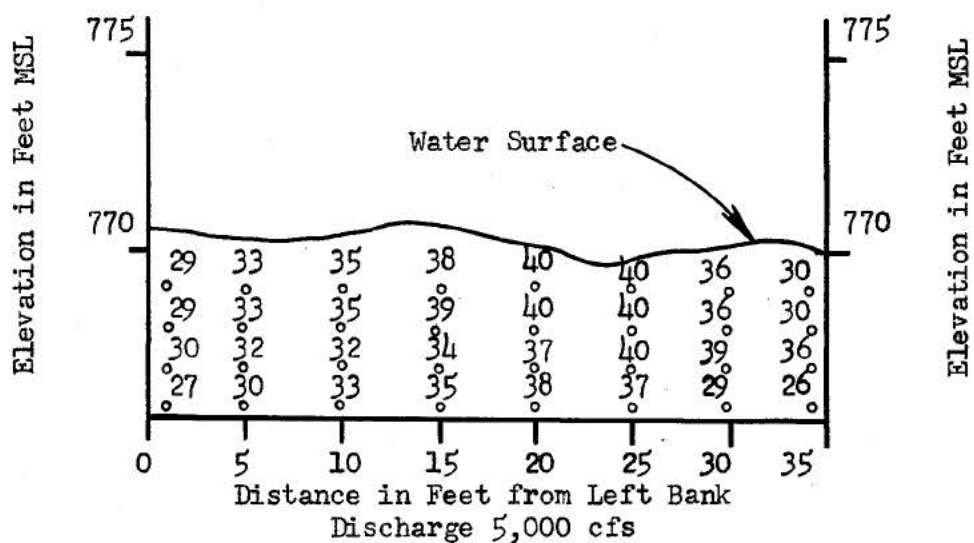
NOTE: Velocities are in feet per second in prototype.

VELOCITIES
TOPHET BROOK
ORIGINAL CULVERT FLUME
STATION 4 + 75



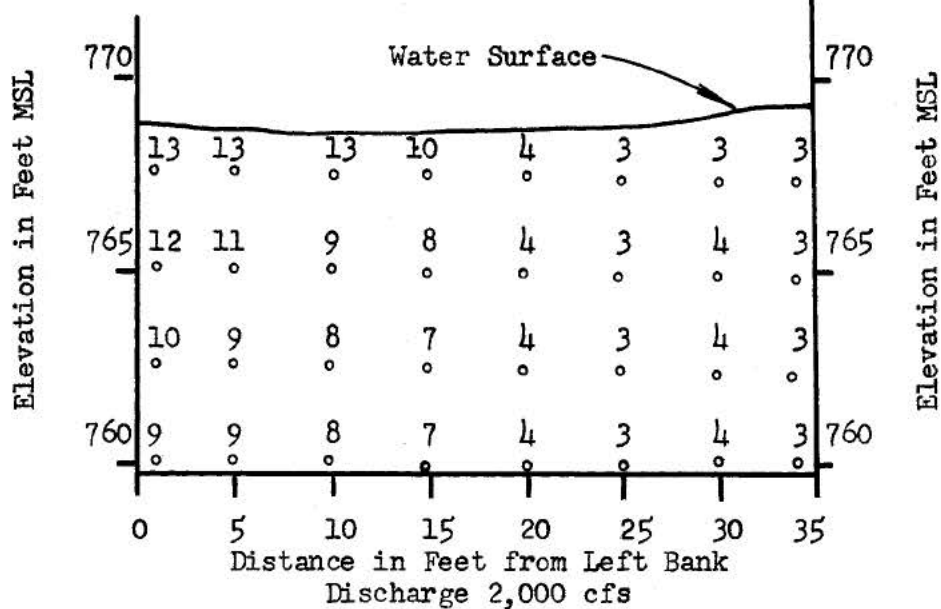
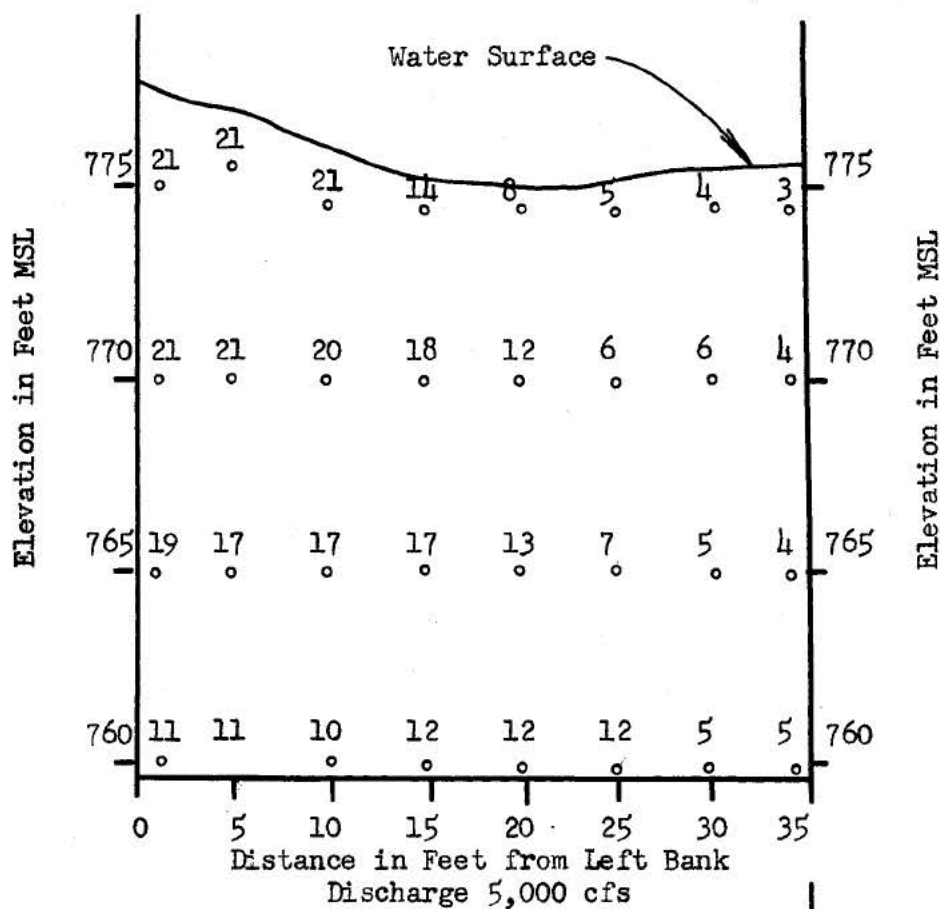
NOTE: Velocities are in feet per second in prototype.

VELOCITIES
TOPHET BROOK
ORIGINAL CULVERT FLUME
STATION 4 + 10



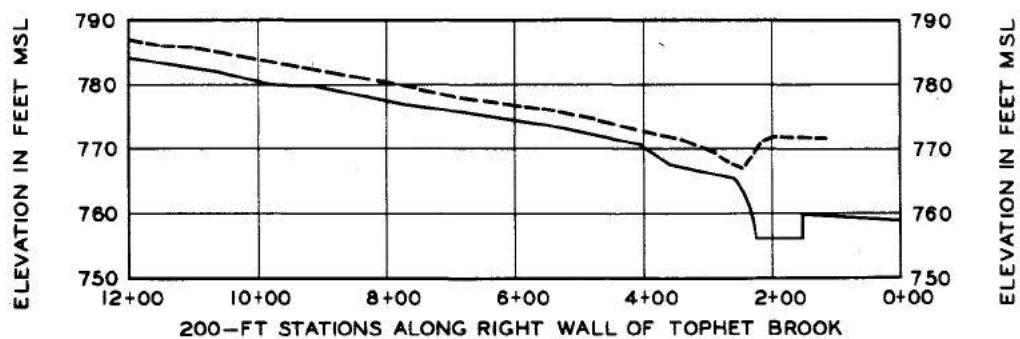
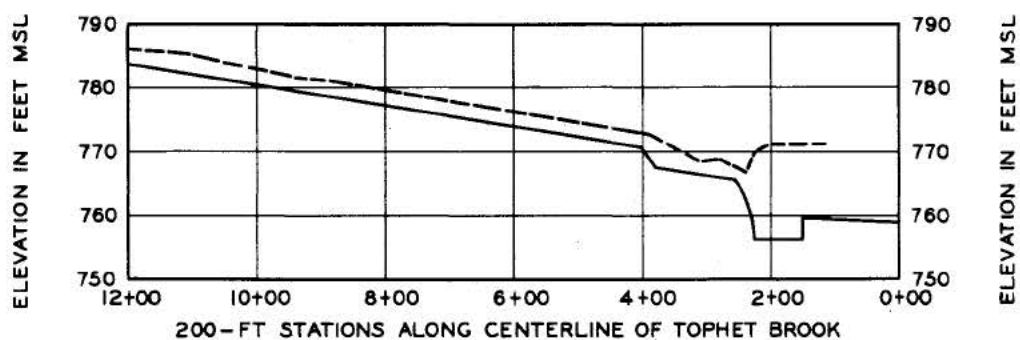
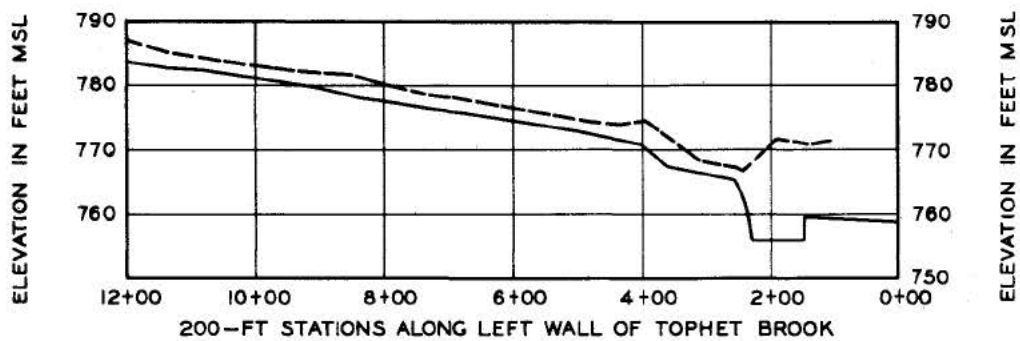
NOTE: Velocities are in feet per second in prototype.

VELOCITIES
TOPHET BROOK
ORIGINAL CULVERT FLUME
STATION 2 + 62.04



NOTE: Velocities are in feet per second in prototype.

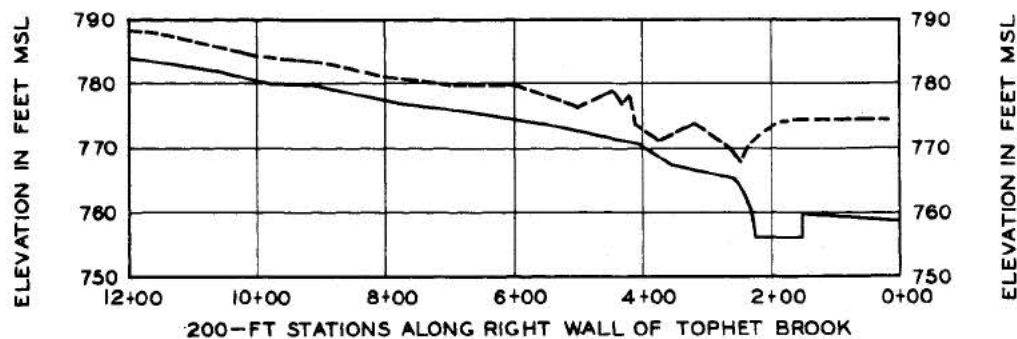
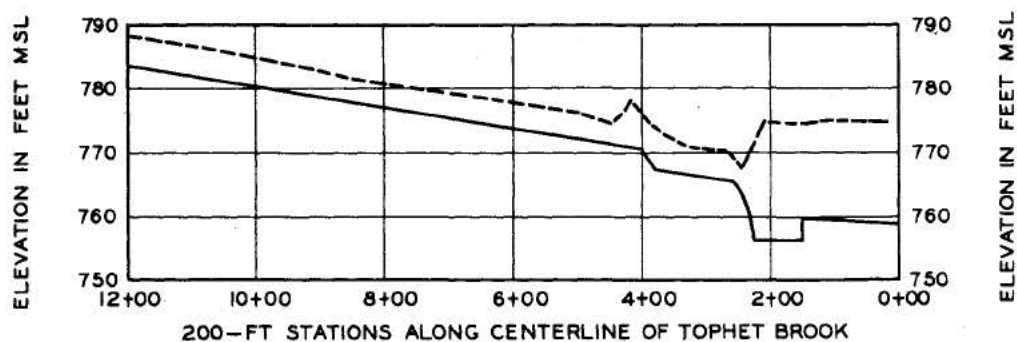
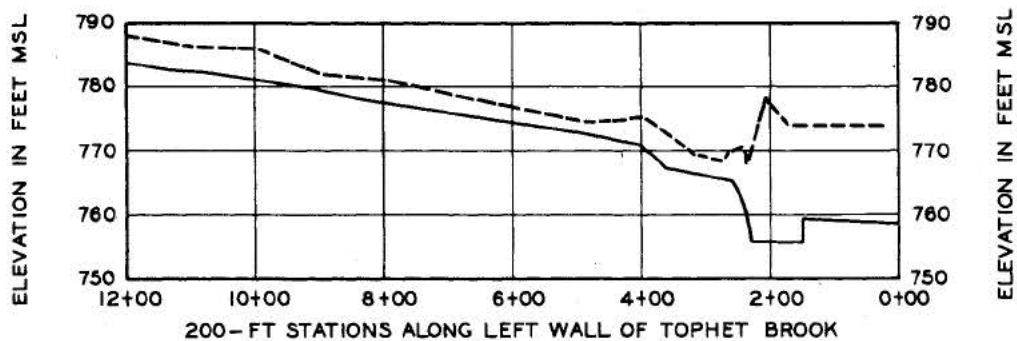
VELOCITIES
TOPHET BROOK
ORIGINAL CULVERT FLUME
STATION 1 + 50



NOTE: TAILWATER CONTROLLED BY
STAGES OF HOOSIC RIVER.
DISCHARGE OF 1,640 CFS IN
TOPHET BROOK SUPPLEMENTED
BY 360 CFS IN CULVERT FLUME.

TOPHET BROOK WATER-SURFACE PROFILES

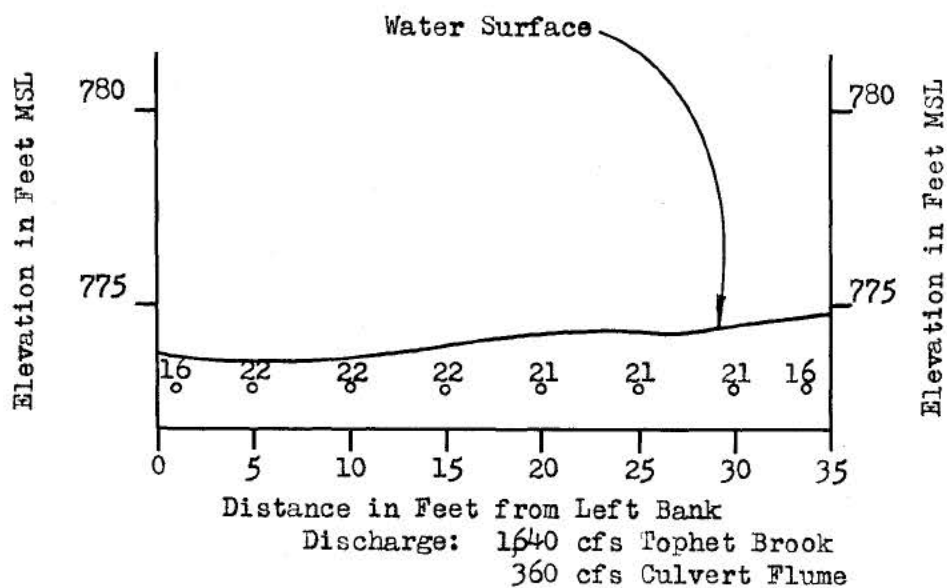
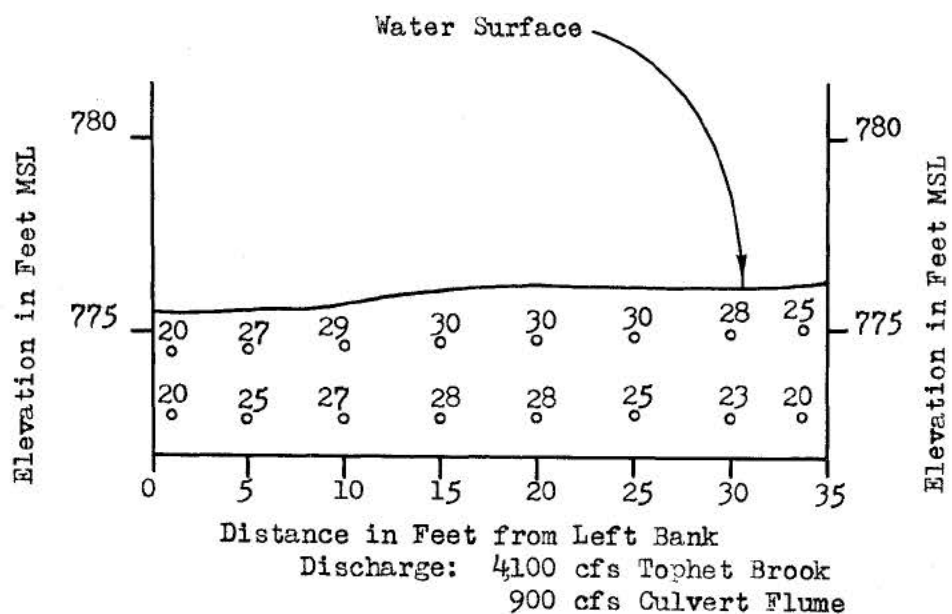
ORIGINAL DESIGN
DISCHARGE 2,000 CFS



NOTE: TAILWATER CONTROLLED BY
STAGES OF HOOSIC RIVER.
DISCHARGE OF 4,100 CFS IN
TOPHET BROOK SUPPLEMENTED
BY 900 CFS IN CULVERT FLUME.

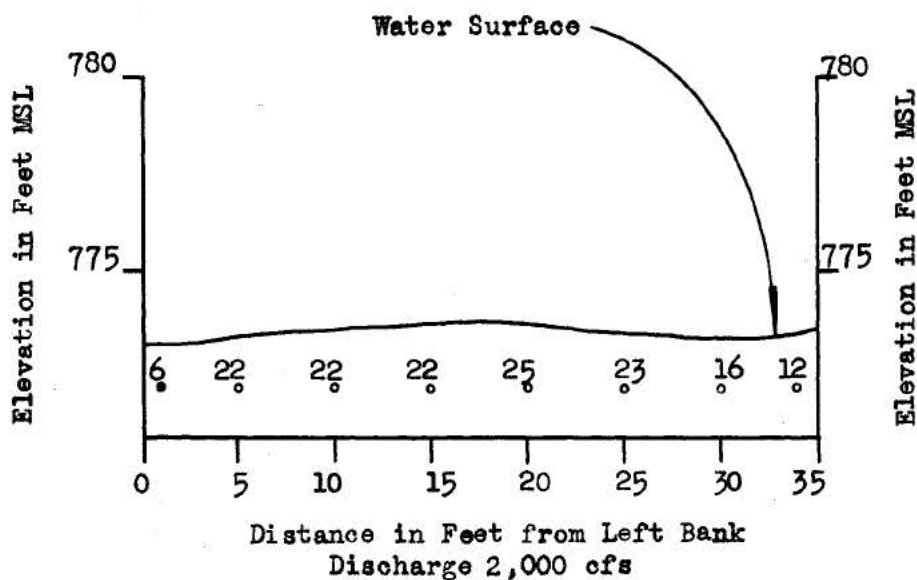
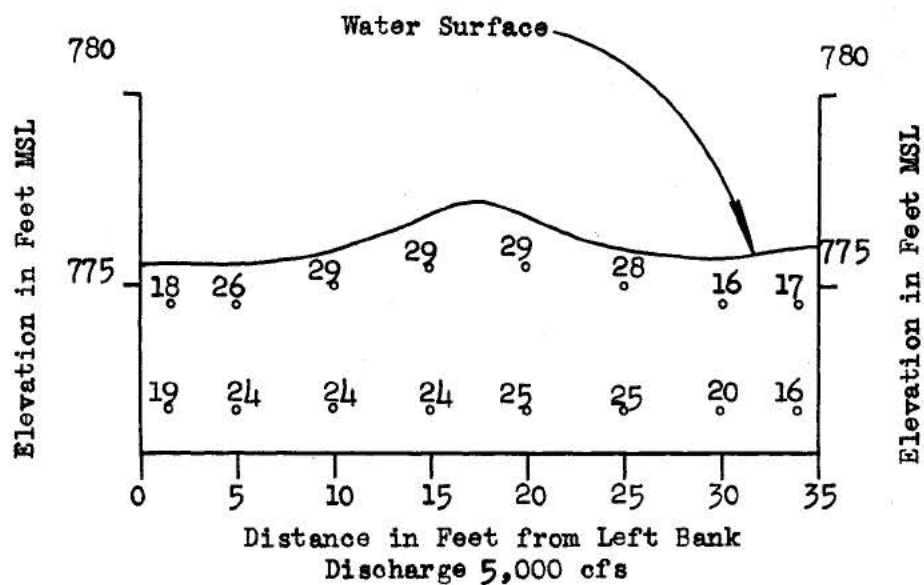
TOPHET BROOK WATER-SURFACE PROFILES

ORIGINAL DESIGN
DISCHARGE 5,000 CFS



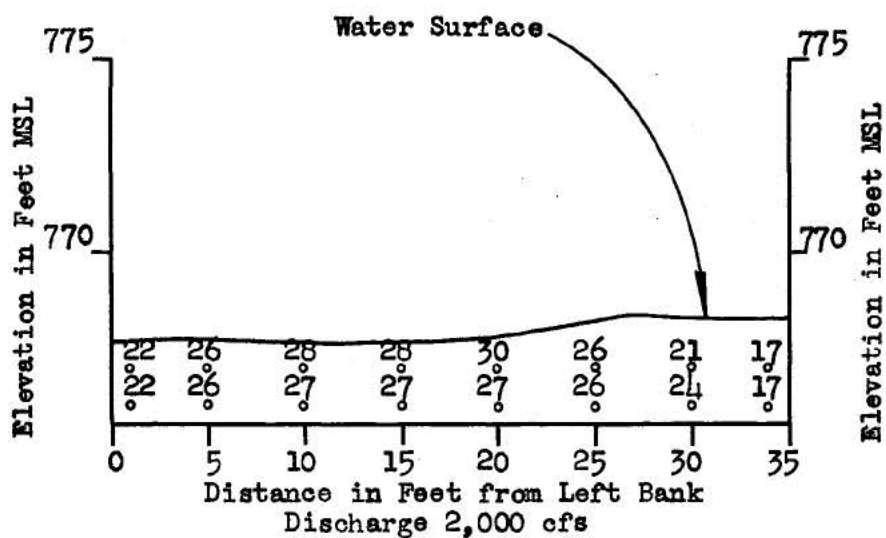
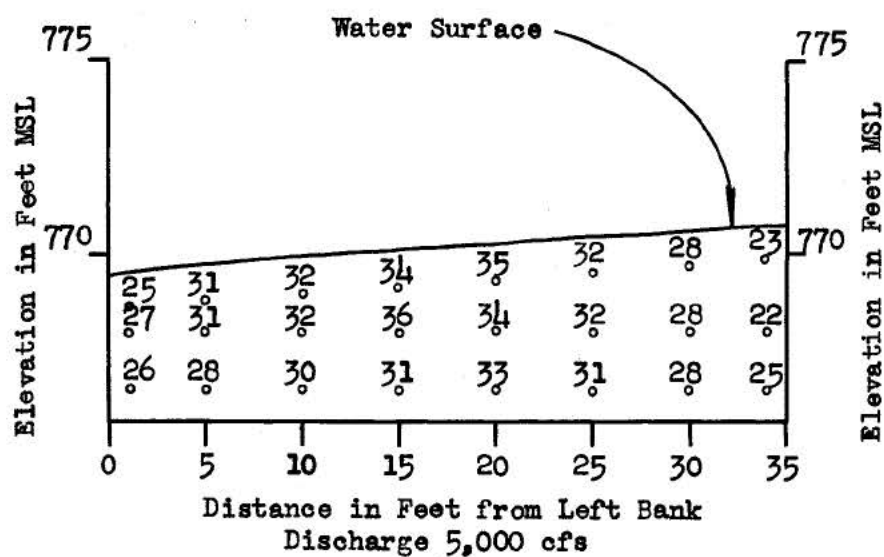
NOTE: Velocities are in feet per second in prototype.

VELOCITIES
TOPHET BROOK
REVISED CULVERT FLUME
STATION 4 + 75



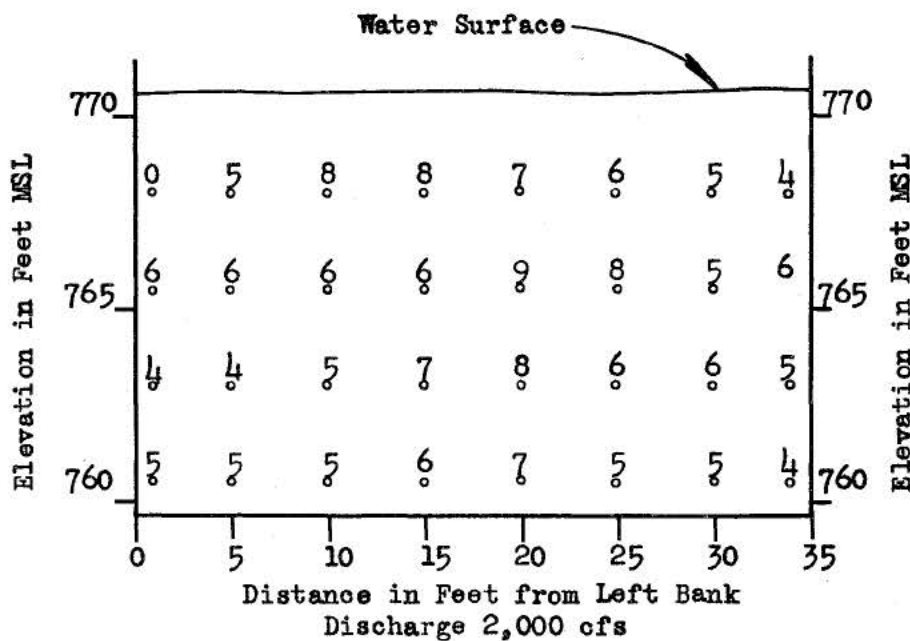
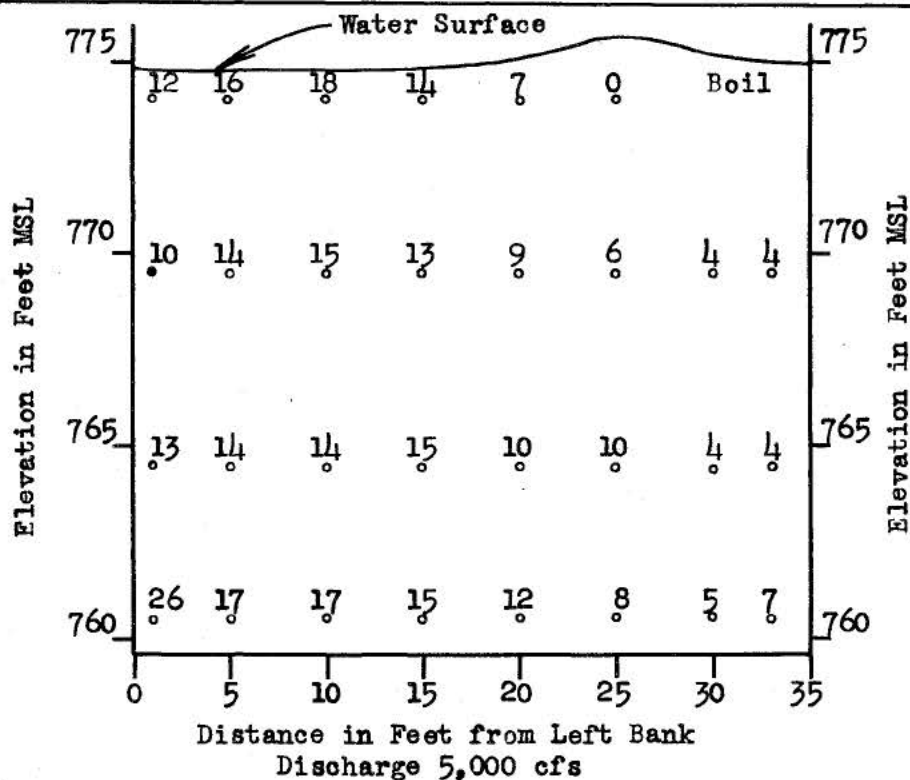
NOTE: Velocities are in feet per second in prototype.

VELOCITIES
TOPHET BROOK
REVISED CULVERT FLUME
STATION 4 + 10



NOTE: Velocities are in feet per second in prototype.

VELOCITIES
TOPHET BROOK
REVISED CULVERT FLUME
STATION 2 + 62.04



NOTE: Velocities are in feet per second in prototype.

VELOCITIES
TOPHET BROOK
REVISED CULVERT FLUME
STATION 1 + 50